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Report.

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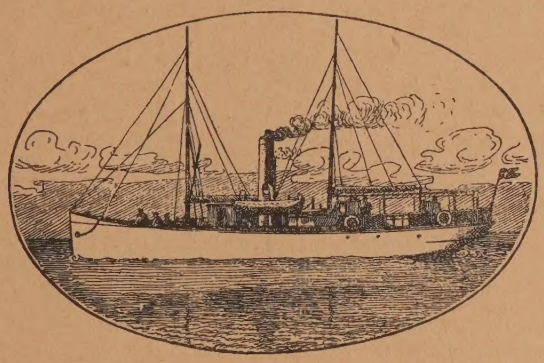
Report

of

The Danish Biological Station

to

The Ministry of Shipping and Fisheries



XXXVII.

1932.

By

H. Blegvad, Ph. D.
Director

Copenhagen. C. A Reitzel.
1932.

The Reports from the Danish Biological Station (Nos. I—XXI) are published in the official Danish "Fiskeri-Beretning" for the years 1890—91 until 1912. After this year they appear as special publications. The Reports I—XXXII are edited by the late Dr. C. G. Joh. Petersen, the Reports XXXIII—XXXVI by Dr. A. C. Johansen the Report XXXVII by Dr. H. Blegvad.

I. *C. G. Joh. Petersen:* Fiskenes biologiske Forhold i Holbæk Fjord. (1890—91)*) 63 pp. 1 Chart. Out of print.

II. *Idem:* On the Eggs and Breeding of our Gobiidæ. (1891—92.) 9 pp. Two Plates. Out of print.

III. *Idem:* The Pelagic Life in Fænø Sound etc. (1892—93.) 38 pp. Tables. Out of print.

IV. *Idem:* On the Biology of our Flat-fishes and on the decrease of our Flat-fish Fisheries. (1893—94.) 146 pp. 2 Plates. 1 Chart. Many Tables. Out of print.

V. *Idem:* The common Eel (*Anguilla vulgaris* T.) gets a Particular Breeding-dress before its Emigration to the Sea. (1894—95.) 35 pp. With 2 Plates.
Etc. 64 pp. Out of print.

VI. *Idem:* The Yearly Immigration of young Plaice into the Limfjord etc. (1895—96). 48 pp. 1 Chart. 2 Tables. Out of print.

VII. *Idem:* Plankton-Studies in the Limfjord. 1897. 23 pp. 1 Map. 4 Tables. Out of print.

VIII. *Idem:* An Otter-Seine for the Exploration of Deeper-Seas. 1898. 24 pp. With 10 Figures. Out of print.

IX. *Idem:* Trawlings in the Skager Rack and the Northern Cattegat in 1897 and 98. 1899. 56 pp. With one Map. Out of print.

X. *Idem:* List of the "Aalerusestader" in Denmark etc. — Smaller Communications. 1899 and 1900. 37 pp.

XI. *Idem:* I. The Biology of the Cod in the Danish Seas. II. On other Codfishes in our Seas. III. Some General Observations on Protection, Legislation etc. IV. Alterations and Improvements on Otter-seines for Zoological Purposes. 1900 and 1901. 44 pp.

XII. *Idem:* I. Where, and under what Conditions, can the Eggs of Plaice be developed into Young Fish within the Skaw? II. On the Young Stages of the genus *Zeugopterus.* (With one Plate). III. Can we enter into Competition with the Foreign Steam-trawlers in our Seas outside the Danish Territorial Limit. 1902 and 1903. 33 pp.

XIII. *A. Otterstrøm:* Eggs and Young of Fishes in the Danish Waters. (Investigations during 1904 and earlier years.) 1903 and 1904. 85 pp.

XIV. I. *C. G. Joh. Petersen:* The Influence of Light on the Migrations of the Eel. II. *K. I. Gemzøe:* Age and Rate of Growth of the Eel. 1906. 39 pp.

XV. *Idem:* I. First Report on the Oysters and Oyster Fisheries in the Lim Fjord. (70 pp.) 1908.

XVI. *C. H. Ostenfeld:* On the Ecology and Distribution of the Grass Wrack (*Zostera marina*) in Danish Waters. With 9 figures. 1908. 62 pp.

XVII. *C. G. Joh. Petersen:* II. Second Report on the Oyster and Oyster Fisheries in the Lim Fjord. 1908. (24 pp).

XVIII. *C. G. Joh. Petersen:* I. The Yield of the Limfjord fisheries in recent years and the transplantation of Plaice in 1908. With 6 tables and 1 Chart. II. Biological investigations on the stock of Plaice in the Limfjord. With 3 Tables. III. The Yield of the Prawn fishery from 1885—1907 and its improvement by means of protection. With 3 Tables. 25 pp. 1909.

XIX. *Idem:* Some Experiments on the Possibility of combating the harmful Animals of the Fisheries, especially the Whelks in the Limfjord. 20 pp. 1911.

XX. *C. G. Joh. Petersen* og *P. Boysen Jensen:* Valuation of the Sea. I. Animal Life of the Sea-Bottom, its food and quantity. With 6 Tables, 3 Charts and 6 Plates. 81 pp. 1911.

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*) The figures in ( ) refer to the "Fiskeri-Beretning" for the years quoted.

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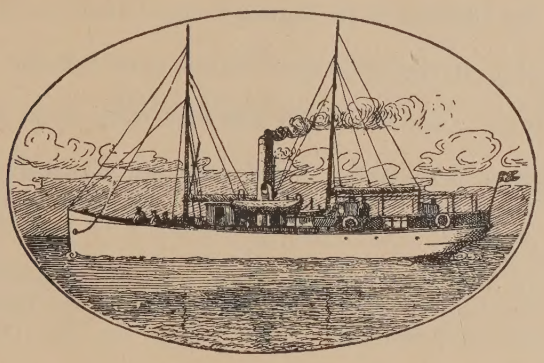

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I.

Investigations of the Bottom Fauna at Outfalls of Drains in the Sound.

By

H. BLEGVAD

On a desire expressed by the Office of the Commissioner of Public Works (Messrs. A. Bjerre, City Engineer and Surveyor, and A. E. Lund and Joh. Funck, Branch Engineers) the Danish Biological Station in May, 1931 carried out a series of investigations in order to ascertain to which extent the bottom fauna of the Sound could be said to suffer from the pollution caused by the large drains of Copenhagen and Gentofte.

The investigations were made by means of the 0.1 sq.m. Petersen Grab (as to description and picture of this gear see Rep. Danish Biol. Stat. XXV, p. 4, Fig. 3). Samples were taken with this gear at 71 stations (see Table 1, p. 12—17), 1 or 2 samples being taken at each station according to the density of the bottom animals ("valuation").

These investigations were supplemented with 18 bottom samples taken by a diver from the Office of the Commissioner of Public Works at the end of October 1931 (St. 81—98, Table 2, p. 18—19). The samples were dug out inside a frame covering 0.1 sq.m. of the bottom, so that they might be compared with the bottom samples earlier taken by the Biological Station. Each sample held abt. 4500 ccm., so that the depth to which the bottom was dug out, was abt. 4.5 cm., i.e. nearly the same depth as is worked by the Petersen Grab in bottom of a similar condition. The comparison is not, however, fully reliable, i.a. because some of the bottom animals will be able to escape from the spade when they are dug out, whereas the Petersen Grab will at once prevent them from escaping. But as regards the bottom animals chiefly dealt with here, viz. chætopods and bivalves that live as in-fauna, there is no great chance for their escaping from the spade of the diver; at any rate, in all cases where the sampling gave the result: no living animals, I should think it permissible to rely on the accuracy of the investigation.

Fig. 1 is a general chart with the situation of all the stations of bottom sampling marked out in circular spots. Stations where only hydrographical investigations were made are designated with a cross and the number of the station. Also the outfalls of the drains are put down on the chart.

As appears from the chart the areas where bottom samples were taken are divided into three sections: A, B, and C; each of these sections is represented on

a larger scale in Figs. 2, 3, and 4, respectively. In the charts Figs. 2—4 the number of each station is given, and further the underlined figures stand for the found quantity

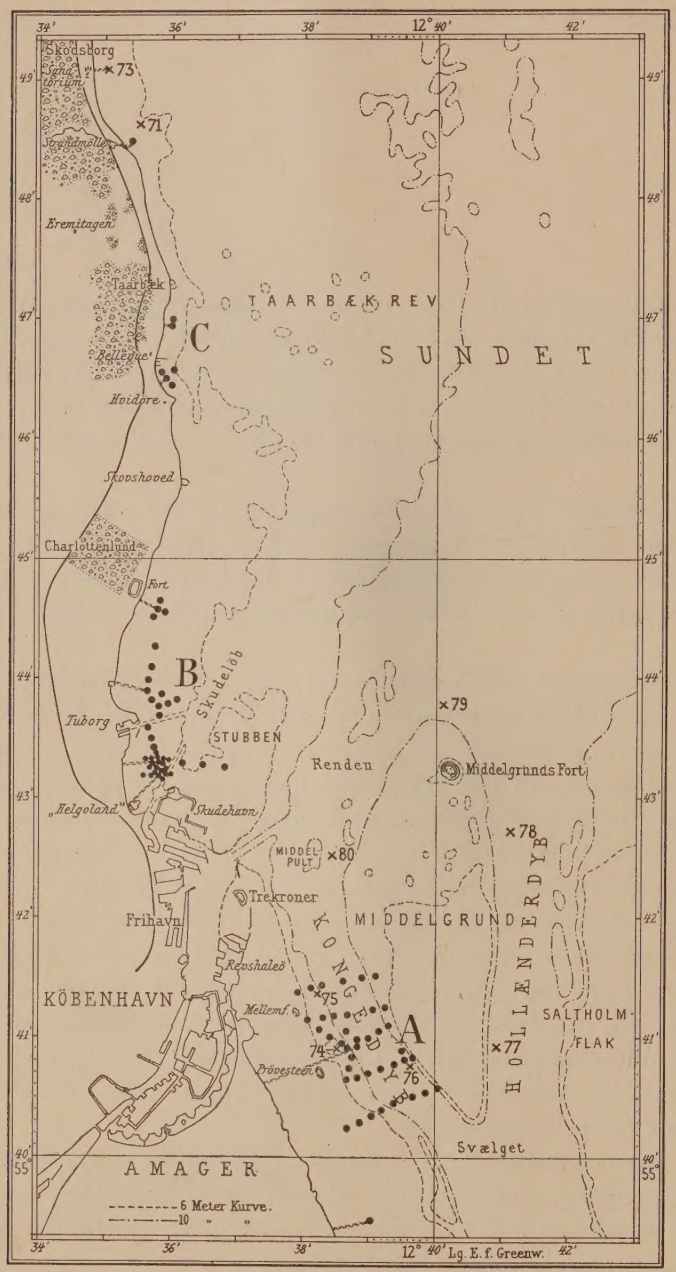

Fig. 1. General chart of valuation stations (without statement of no.) and hydrographical stations (nos. stated) at the outfalls of drains into the Sound at Copenhagen and Gentofte. The outfalls are marked down in the chart with broken double lines.

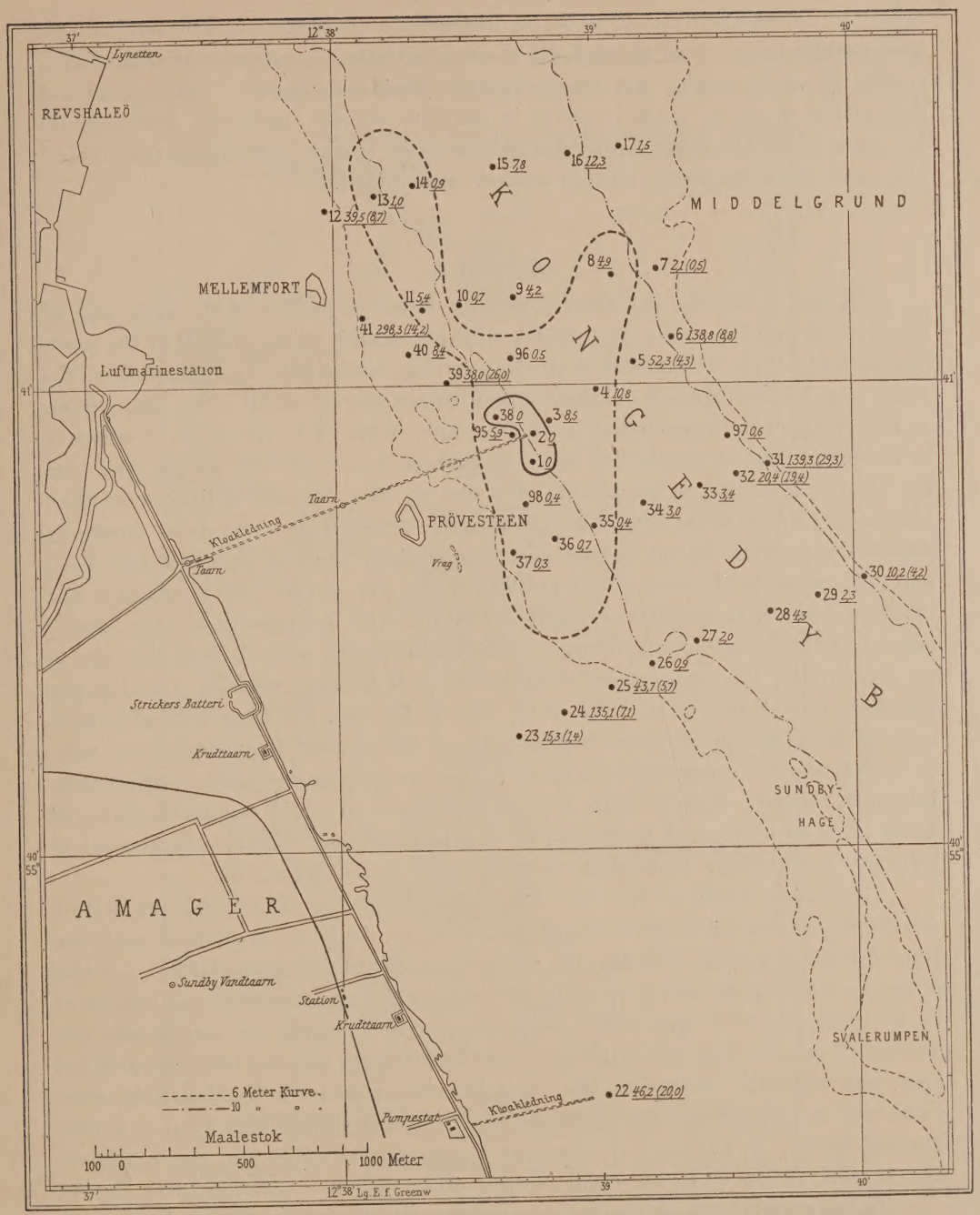

Fig. 2. Special chart of valuation stations within Section A (see Fig. 1). Besides the no. of the station the weight figure for the bottom animals is stated for each station in g. per 0.1 sq.m. Where the whole of the quantity found was not fish food, the amount of fish food, too, has been added in brackets in g. per 0.1 sq.m. The continuous curve shows the bottom area in which no living animals were found. The broken curve designates the area, in which the bottom was fetid.

of bottom animals in g. per 0.1 sq.m. In cases where part of the found bottom animals were not fish food — this is especially the case with the big mussels (*Mytilus edulis*), cockles (*Cardium edule*), and the periwinkle (*Littorina littorea*) — the amount of fish food in g. per 0.1 sq.m. is given in brackets. Finally the dotted lines indicate the areas where the bottom consisted of fetid ooze, and the continuous lines denote the areas where no living bottom animals were found.

Section A.

Section A includes the bottom samples round the outfall of the main pipe of the Kløvermarksvej Drain together with one sample at the outfall of the drain Sundby Distrikt III, which is situated farther southwards. It appears from the chart Fig. 2 and Tables 1—2 that only a comparatively small area, abt. 200 m. to both sides of the main outfall in the direction N.W.—S.E. (direction of current), is absolutely void of animal life: here the bottom is covered with sewage offal that has smothered all life of the bottom. But already at a distance of little more than 100 m. to the N.E. of the outfall of the drain (St. 3) were found very many unusually high-fed polychætes of the species *Scoloplas armiger*, which is excellent fish food; and only 80 m. to the west of the outfall (St. 95) were found both polychætes and bivalves. Indeed, at these two stations and all the other stations outside the "dead" area of section A are found so large quantities of bottom animals that they are in no way inferior to corresponding localities situated far from outfalls of drains (see e.g. Rep. Danish Biol. Stat. XXI, 1913, App. p. 53—54). The large bulk of bottom animals found at the stations on both sides of the channel (Kongedybet) in comparatively shallow water and hard sandy bottom are principally made up of accumulations of mussels, *Mytilus edulis*, a considerable part of which cannot be devoured by the fish on account of their size; so at several of these stations the amount of fish food is materially lower than at the stations in the channel.

In the area which on the chart Fig. 2 is enclosed in a dotted line, the bottom was fetid and contained sulphuretted hydrogen, no doubt on account of pollution from the main outfall. Possibly the incurvation of the northern part of the line is due to a deepening having recently been made; thus the nature of the bottom at St. 10: pure clay of a light colour, suggests a recent dredging. As will be seen the amount of animals was still rather considerable in many places within the polluted area, and especially chætopods like *Scoloplas armiger* and *Nereis diversicolor* seem to do well in this bottom; the specimens of the former species were even unusually big and heavy, an evidence of abundant feeding matter. But also small bivalves like *Macoma baltica* and even small *Mytilus edulis* may live here (Stats. 8, 13, 14).

In one sample taken on sandy bottom off the outfall of the smaller drain "Sundby Distrikt III" (St. 22) was found a large quantity of animals, principally consisting of mussels and cockles. Here, then, could be ascertained no influence at all of the pollution of the sewage on the bottom fauna.

Section B.

This section includes bottom samples at the two drains in Svanemøllebugten (the Svanemølle Drain and the Scherfigsvej Drain, marked I and II, resp.,

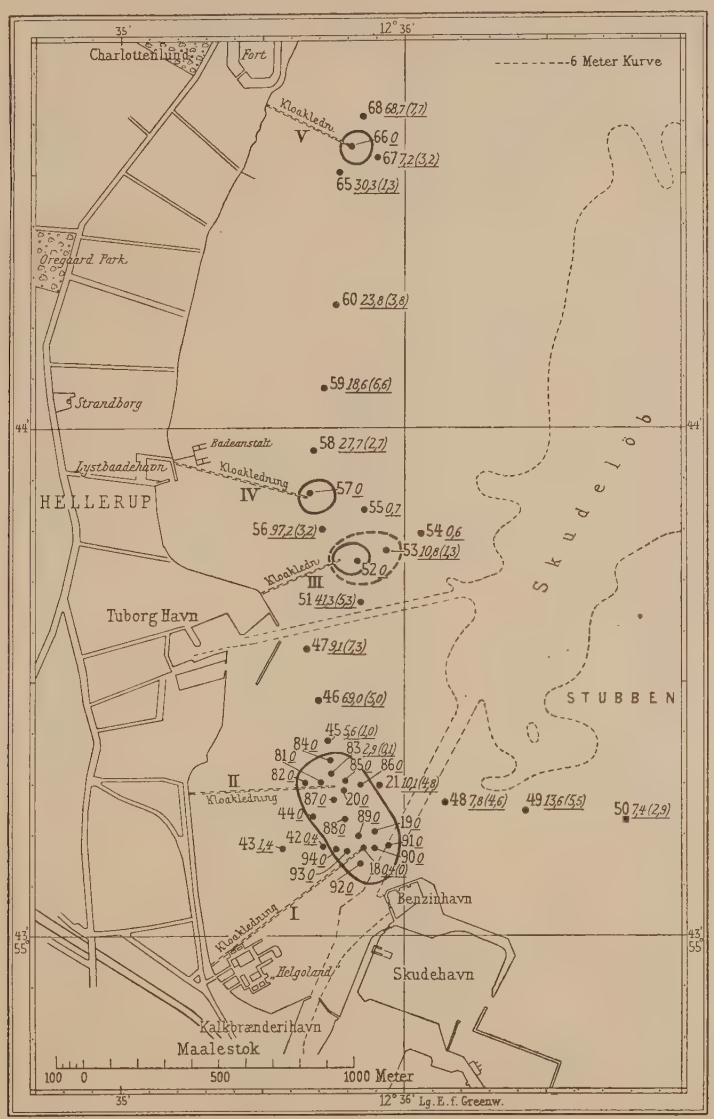

Fig. 3. Special chart of valuation stations in Section B. For explanation see Fig. 2.

in Fig. 3), at Tuborg Harbour (III), Hellerup Harbour (IV), and Charlottenlund Fort (V).

In the area round the outfalls of Drains I and II in Svanemøllebugten was found a vast continuous area with no living animals in and on the bottom; this

"dead" area is abt. 300 × 600 m. and on the chart Fig. 3 it is surrounded by a continuous curve. It is true that three quite small ascidia were found at St. 18

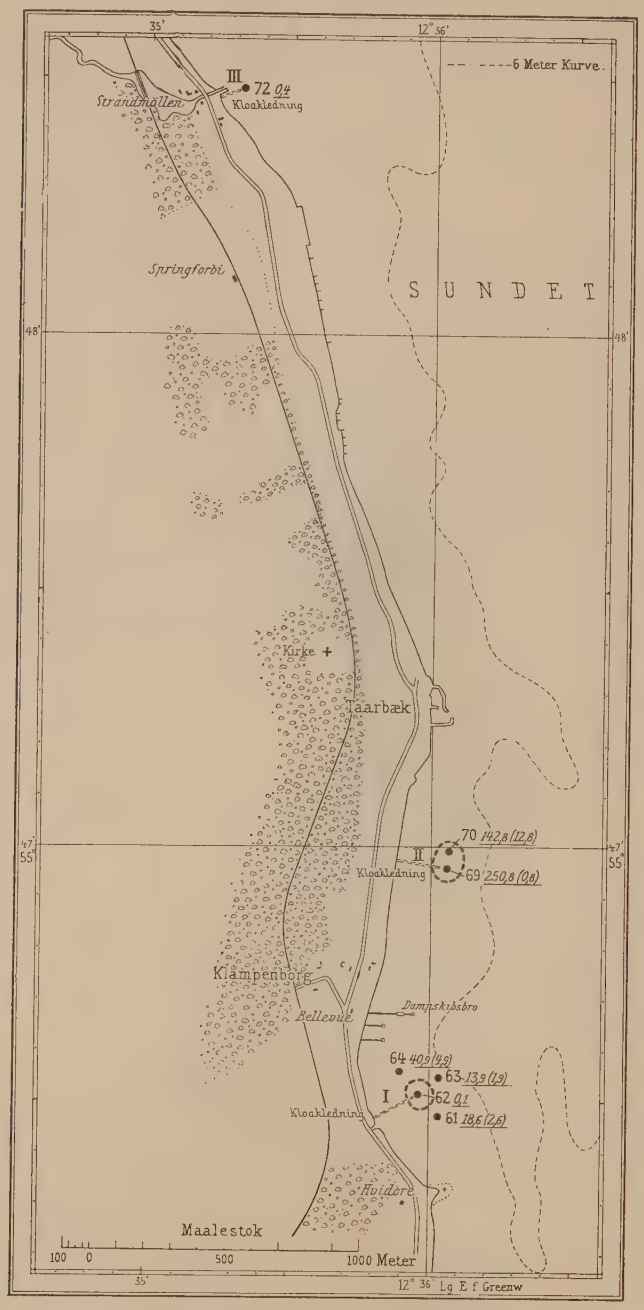

Fig. 4. Special chart of valuation stations in Section C. For explanation see Fig. 2.

immediately off the mouth of the Svanemølle drain-pipe, but it is doubtful whether they were stationary. As will be seen St. 83 makes out a little enclave within the "dead" area, some few bivalves and gasteropods being found here. In contrast with conditions at the Kløvermarksvej main pipe there is in Svanemøllebugten outside the "dead" area no bottom area with distinct traces of sewage pollution but with a comparatively rich animal life, i.e. the effect of the sewage pollution is exclusively destructive to the bottom animals. The rich fauna of polychætes that was met with at the main pipe of Kløvermarksvej, and which benefits from the organic matter carried to the bottom from the drains, was not found here. As a matter of fact not one *Scoloplas armiger* occurred in Svanemøllebugten, though it was so numerously represented at the main pipe of the Kløvermarksvej. These conditions are no doubt due to Svanemøllebugten being situated in a corner between two long piers. The polluted waters in the bay therefore will sometimes be stagnant; under certain conditions of wind and current they may come to rotate within a narrow area. In both cases the sewage water will have time to deposit the suspended particles in a degree that is destructive to the bottom fauna.

At the other drains, III, IV, and V, there is but a very limited area with no bottom fauna round the outfalls; already at a distance of abt. 100 m. from the outfalls there is a comparatively rich animal life. Off the outfall of the Tuborg Drain (No. III) there is an area with fetid bottom but rather a rich fauna of bivalves and gasteropods. At the other drains the bottom is fresh already at a short distance (100—200 m.) from the outfall.

Outside the "dead" areas especially bivalves dominate in number and quantity at all the drains; first and foremost the mussel *Mytilus edulis*, but also the cockle *Cardium edule* and the clam *Mya arenaria* give rather heavy weights, but the bivalve which is most important as fish food, is the small pink *Macoma baltica*. As will be seen, the figures for fish food, however, are small everywhere.

Section C.

Fig. 4 shows the situation of the stations in Section C, which includes the outfalls of drains at Klampenborg (I), Taarbæk (II), and Strandmøllen (III). At none of these drains was found any "dead" area, but at the outfall of Drain I was found only a small chætopod (St. 62, Table 1). However, it should be noted that these investigations were made under rather unfavourable conditions, the wind being inshore and the sea rough. At the outfalls of Drains I and II there was a limited area, abt. 100 m. to both sides of the outfall, with a fetid bottom containing sulphuretted hydrogen, but in spite of this there was a very rich animal life, with large quantities of mussels, especially at Drain II. At Drain II no traces of pollution were found, but then only one sample was taken.

Tabel 1. Stationer med Peterse
Antal og Raavægt af Bun

Table 1. Stations with the "Peterse
Number and Rough Weight of

Station Nr.	1		2		3		4		5		6		7		8		9		10	
Dybde i m. *Depth in m.*	8		8		16		15		14		9		7		14		14		15	
A. = Antal, V. = Raavægt i g. A. = *Number*, V. = *Rough Weight in g.*	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V
Macoma baltica	..	..	..	..	1	0.3	8	0.6	14	2.1	2	0.2	7	0.4	22	2.6	42	3.9	..	.
Mya arenaria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Scrobicularia plana	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Spisula subtruncata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Cardium edule	..	..	..	..	..	..	..	..	1	0.5	..	..	..	..	..	..	..	..	..	.
Mytilus edulis	..	..	..	..	..	..	1	0.7	8	48.0	76	138.2	2	1.7	..	..	..	..	..	.
Littorina littorea	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
— tenebrosa	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Hydrobia ulvæ	..	..	..	..	..	..	9	0.1	..	..	25	0.1	..	..	..	..	..	..	..	.
Utriculus obtusus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Eteone longa	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Nereis diversicolor	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	0.1	..	..	1	0.
Scoloplos armiger	..	..	..	..	140	8.2	180	9.4	28	0.9	..	..	..	..	41	0.7	1	0.1	25	0.
Arenicola marina	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	1.4	..	..	..	.
Ampharete grubei	..	..	..	..	..	..	..	..	25	0.8	..	..	..	..	3	0.1	3	0.1	..	.
Halicryptus spinulosus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Nemertini	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	0.
Calliopius rathkei	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Bathyporeia robertsonii	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Gammarus locusta	..	..	..	..	..	..	..	..	..	..	1	0.1	..	..	..	..	..	..	..	.
Amphithoë rubricata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Idothea baltica	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
— viridis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Diastylis rathkei	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	0.1	..	.
Carcinus mænas	..	..	..	..	..	..	..	..	..	..	1	0.2	..	..	..	..	..	..	..	.
Crangon vulgaris	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Ophiura albida	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Ciona intestinalis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.
Antal. *Number*	0	..	0	..	141	..	198	..	76	..	105	..	9	..	70	..	47	..	27	.
Raavægt. *Rough Weight*	..	0	..	0	..	8.5	..	10.8	..	52.3	..	138.8	..	2.1	..	4.9	..	4.2	..	0.
Fiskeføde, Raavægt i g pr. 0.1 m². *Fish Food, Rough Weight in g per 0.1 sq.m.*	0		0		8.5		10.8		4.3		8.8		0.5		4.9		4.2		0.7	
Bundart. *Nature of Bottom*	Sort Sand, Slagger, enkelte organiske Bestanddele *Black sand, cinders, a few organic constituents*		Fæces og andet Kloakaffald *Fæces and other sewage offal*		Sort Slam *Black ooze*		Sort, stinkende Mudder *Black, fetid mud*		Ren Bund, *Pure Bottom,* } Mytilus		Ren Bund, *Pure Bottom,* } Mytilus		Mørkt Sand *Dark sand*		Sort, stinkende Mudder *Black, fetid mud*		Sort Mudder *Black mud*		Lyst Ler, rent *Light, pure clay*	

n² Bundhenter. 1.—11. Maj 1931.
ne i g pr. 0.1 m².
" of 0.1 sq. m. May, 1.—11., 1931.
n Animals in g per 0.1 sq. m.

	12		13		14		15		16		17		18		19		20		21		22		23		24	
	4		9		14		14		12		7		3.5		4.5		3		5		2.5		4.5		5	
	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.
	..	..	6	0.5	2	0.2	..	..	27	6.0	5	0.8	..	..	..	..	..	..	2	1.3	1.0	0.3	15	0.6	6	0.5
	4	0.5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1.5	0.2	2	0.3	3	0.4
	..	..	..	..	..	..	..	..	3	3.7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	1	0.5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	16.5	10.2	2	0.2	1	0.1
	27	37.8	1	0.1	1	0.2	..	..	..	..	..	..	..	..	..	..	..	..	4	3.0	30.0	34.7	6	14.2	45	129.5
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	5.3	2.5	0.7	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	0.2	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	0.1	..	..	..	..	10	0.3
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
9	1	0.1	1	0.1	..	..	..	..	..	..	1	0.2	..	..	..	..	..	..	4	0.2	..	..	..	..	38	3.6
1	1	0.1	1	0.1	4	0.4	170	7.8	2	0.1	1	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	56	2.0	2	0.2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	1	0.5	1	0.2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	1	0.2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	9	0.3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	12	0.6
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.5	0.1	..	..	..	..
	5	0.2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	0.1
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	1	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	3	0.4	..	..	..	..	..	..	..	..	..	..	..	..
	48	..	10	..	8	..	170	..	89	..	10	..	3	..	0	..	0	..	24	..	52	..	25	..	116	..
4	..	39.5	..	1.0	..	0.9	..	7.8	..	12.3	..	1.5	..	0.4	..	0	..	0	..	10.1	..	46.2	..	15.3	..	135.1
	8.7		**1.0**		**0.9**		**7.8**		**12.3**		**1.5**		**0**		**0**		**0**		**4.8**		**20.0**		**1.4**		**7.1**	
	Sand		Sort, stinkende Mudder *Black, fetid mud*		Sort, stinkende Mudder *Black, fetid mud*		Sort Mudder med Sand, lugtfrit *Black mud with sand, no smell*		Sort Mudder, lugtfrit *Black mud, no smell*		Sand		Sort, stinkende, sandet Kloakaffald *Black, fetid sewage waste with sand*		Sort, stinkende, sandet Kloakaffald *Black, fetid sewage dregs with sand*		Sort, stinkende Sand *Black, fetid sand*		Mudder med Sand, frisk Zostera *Mud with sand, fresh Zostera*		Sand, Smaasten *Sand, pebbles*		Sand		Sort Mudder *Black mud*	

Tabel 1 (fortsat)

Station Nr.	25		26		27		28		29		30		31		32		33		34	
Dybde i m *Depth in m.*	5.5		6.5		13		13		13		7		6		12		14		14	
A. = Antal, V. = Raavægt i g A. = *Number*, V. = *Rough Weight in g.*	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	A.	V.	A.	A.	V.	A.	V.
Macoma baltica	8	0.5	1	0.1	..	..	37	2.5	22	1.8	2	0.1	4	0.6	40	10.3	16	0.6	17	0.6
Mya arenaria	5	1.4	..	..	..	..	1	0.8	..	..	..	..	..	..	..	..	..	..	1	0.1
Scrobicularia plana	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Spisula subtruncata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cardium edule	..	..	..	..	..	..	1	1.0	1	0.1	..	..	..	..	15	7.5	1	0.1	..	..
Mytilus edulis	12	36.3	..	..	2	1.0	..	..	..	..	17	9.2	119	138.5	..	..	..	..	..	..
Littorina littorea	5	3.3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
— tenebrosa	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Hydrobia ulvæ	5	0.1	..	..	..	..	..	..	1	0.1	3	0.1	..	..	..	..	1	0.1	7	0.2
Utriculus obtusus	..	..	..	..	..	..	..	..	1	0.1	..	..	..	..	..	..	1	0.1	..	..
Eteone longa	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Nereis diversicolor	15	1.8	5	0.5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Scoloplos armiger	..	..	..	..	11	1.0	..	..	7	0.2	6	0.3	..	..	..	..	87	2.2	67	2.1
Arenicola marina	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ampharete grubei	..	..	..	..	..	..	..	..	..	..	..	..	..	..	43	2.6	5	0.3	..	..
Halicryptus spinulosus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Nemertini	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Calliopius rathkei	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Bathyporeia robertsonii	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gammarus locusta	8	0.3	1	0.2	..	..	..	..	..	..	3	0.4	1	0.1	..	..	..	..	..	..
Amphithoë rubricata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Idothea baltica	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
— viridis	..	..	1	0.1	..	..	..	..	..	..	..	..	1	0.1	..	..	..	..	..	..
Diastylis rathkei	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Carcinus mænas	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Crangon vulgaris	..	..	..	..	..	..	..	..	..	..	1	0.1	..	..	..	..	..	..	..	..
Ophiura albida	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ciona intestinalis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Antal *Number*	58	..	8	..	13	..	39	..	32	..	32	..	125	..	98	..	111	..	92	..
Raavægt *Rough Weight*	..	43.7	..	0.9	..	2.0	..	4.3	..	2.3	..	10.2	..	139.3	..	20.4	..	3.4	..	3.0
Fiskeføde, Raavægt i g pr. 0.1 m² *Fish Food, Rough Weight in g per 0.1 sq.m.*	**5.7**		**0.9**		**2.0**		**4.3**		**2.3**		**4.2**		**29.3**		**19.4**		**3.4**		**3.0**	
Bundart *Nature of Bottom*	Mørkt Mudder med Sten *Dark mud with pebbles*		Mørkt Mudder *Dark mud*		Mørkt Mudder, Smaasten *Dark mud, pebbles*		Graat Mudder *Gray mud*		Mørkt Mudder med Sand *Dark mud with sand*		Sand og Sten *sand and stones*		Sand, Sten, døde Skaller og Dødtang *Sand, stones, shells and dead weed*		Mørkt Mudder og Sand *Dark mud and sand*		Mørkt Sand og Mudder *Dark sand and mud*		Mudder, Sand og Sten *Mud, sand and stones*	

ble 1 (continued).

5	36		37		38		39		40		41		42		43		44		45		46		47		48	
4	7.5		7		8		6.5		6.5		7.5		4		3		3.5		4.5		3.5		4.5		6	
V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.
..	..	..	..	..	..	..	24	3.7	59	5.6	15	5.0	..	..	9.5	0.6	..	..	0.5	0.1	12.0	2.5	3.0	1.0	25.0	1.8
..	..	..	..	..	..	..	26	8.5	4	0.6	1	4.7	..	..	2.5	0.4	..	..	1.5	0.2	4.5	1.3	5.0	1.5	2.0	0.2
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.5	0.1	..	..
..	..	..	..	..	..	..	19	23.3	8	1.3	1	4.0	..	..	..	..	..	..	..	..	2.0	0.2	4.0	3.3	2.0	1.8
..	..	..	..	..	..	..	..	..	..	..	57	284.0	..	..	..	..	..	..	2.5	4.7	47.5	63.8	2.5	2.1	1.5	2.3
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2.0	0.7	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	1	0.1	..	..	..	..	..	..	..	..	..	..	0.5	0.1	0.5	0.1
..	..	..	..	..	..	..	..	..	..	..	21	0.5	0.5	0.1	..	..	..	..	19.0	0.3	7.5	0.1	60.0	0.8	70.0	0.9
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.5	0.1	..	..
..	1	0.2	2	0.3	..	..	20	2.5	1	0.6	..	..	0.5	0.1	10.0	0.4	..	..	1.0	0.2	..	..	..	..	4.0	0.3
0.4	8	0.4	..	..	..	..	..	..	1	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	1	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.5	0.1	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	1	0.2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	0.5	0.1	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3.0	0.2	..	..	0.5	0.1
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	0.5	0.1	..	..	..	..	..	..	1.0	0.1	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.5	0.1	0.5	0.1	0.5	0.1
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.5	0.2
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	10	..	2	..	0	..	89	..	74	..	96	..	2.0	..	22.0	..	0	..	25.0	..	80	..	76.5	..	106.5	..
0.4	..	0.7	..	0.3	..	0	..	38.0	..	8.4	..	298.3	..	0.4	..	1.4	..	0	..	5.6	..	69.0	..	9.1	..	7.8
.4	0.7		0.3		0		26.0		8.4		14.2		0.4		1.4		0		1.0		5.0		7.3		4.6	
Fetid mud	Sort, stærkt stinkende Mudder *Black, very fetid mud*		Sand og stinkende Mudder *Sand and fetid mud*		Sort Kloakslam *Black sewage ooze*		Sand med lidt Mudder *Sand and a little mud*		Mørkt Mudder med lidt Sand *Dark mud with a little sand*		Mørkt Sand *Dark sand*		Mørkt Sand med Mudder *Dark sand with mud*		Mørkt Sand med Mudder *Dark sand with mud*		Sand og Mudder *Sand and mud*		Lys Sand med frisk Zostera *Light sand with fresh Zostera*		Lyst Sand med frisk Zostera *Light sand with fresh Zostera*		Lyst Sand *Light sand*	

Tabel 1 (fortsat).

Station Nr.	49		50		51		52		53		54		55		56		57	
Dybde i m *Depth in m.*	6		6		4		4.5		6.5		6.5		6		4		3.5	
A. = Antal, V. = Raavægt i g. A. = *Number*, V. = *Rough Weight in g.*	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.
Macoma baltica	18.5	0.7	11.5	1.0	7.5	2.2	..	..	..	..	1.5	0.1	..	..	1.0	0.5	..	..
Mya arenaria	2.0	0.2	..	..	..	..	..	..	..	..	..	..	..	..	0.5	0.1	..	..
Scrobicularia plana	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Spisula subtruncata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cardium edule	2.0	1.4	3.0	0.5	1.5	0.1	..	..	..	..	5.5	0.3	1.0	0.1	..	..	..	..
Mytilus edulis	6.0	8.1	4.5	4.9	37.0	37.2	..	..	6.0	10.5	..	..	0.5	0.2	42.0	96.0	..	..
Littorina littorea	1.0	0.2	0.5	0.1	0.5	0.1	..	..	0.5	0.1	..	..	..	..	..	..	..	..
— tenebrosa	..	..	..	..	7.5	0.3	..	..	2.0	0.1	..	..	..	..	0.5	0.1	..	..
Hydrobia ulvæ	210.0	3.0	50.5	0.5	47.5	0.9	..	..	..	..	5.5	0.1	11.0	0.2	5.0	0.1	..	..
Utriculus obtusus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Eteone longa	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Nereis diversicolor	..	..	0.5	0.1	..	..	..	..	..	..	0.5	0.1	0.5	0.1	..	..	..	..
Scoloplos armiger	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Arenicola marina	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ampharete grubei	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Halicryptus spinulosus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Nemertini	..	..	0.5	0.2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Calliopius rathkei	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Bathyporeia robertsonii	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gammarus locusta	..	..	..	..	1.0	0.2	..	..	..	..	..	..	..	..	3.0	0.3	..	..
Amphithoë rubricata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Idothea baltica	..	..	0.5	0.1	1.0	0.1	..	..	..	..	..	..	..	..	..	..	..	..
— viridis	..	..	..	..	2.5	0.2	..	..	0.5	0.1	..	..	0.5	0.1	0.5	0.1	..	..
Diastylis rathkei	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Carcinus mænas	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Crangon vulgaris	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ophiura albida	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ciona intestinalis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Antal *Number*	239.5	..	71.5	..	106.0	..	0	..	9.0	..	13.0	..	13.5	..	52.5	..	0	..
Raavægt *Rough Weight*	..	13.6	..	7.4	..	41.3	..	0	..	10.8	..	0.6	..	0.7	..	97.2	..	0
Fiskeføde, Raavægt i g pr. 0.1 m². *Fish Food, Rough Weight in g per 0.1 sq.m.*	5.5		2.9		5.3		0		1.3		0.6		0.7		3.2		0	
Bundart *Nature of Bottom*	Lyst Sand *Light sand*		Lyst Sand *Light sand*		Sand med frisk Zostera *Sand with fresh Zostera*		Sort, stærkt svovlbrintestinkende Mudder *Black mud, stinking with sulphuretted hydrogen*		Sand, sort, stinkende Mudder og Dødtang *Sand, black fetid mud and dead weed*		Sand, Grus, Smaasten *Sand, gravel, pebbles*		Ler, Sand, Smaasten *Clay, sand, pebbles*		Mørkt Sand og Mudder, Sten og Lerklumper *Dark sand and mud, stones and clay*		Sort, meget ildelugtende Sand og Grus *Black, very fetid sand and gravel*	

Table 1 (continued).

3	59		60		61		62		63		64		65		66		67		68		69		70		72	
5	5		4		4.5		5		6.5		5		5		3.5		5		4		3		3		1	
V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.
0.5	1.0	0.4	4.0	1.3	4.0	0.6	..	..	1.0	0.1	2.5	0.7	..	..	..	..	0.5	0.3	7.0	1.1	..	..	2	0.6	3	0.2
0.1	0.5	0.1	..	..	1.5	0.3	..	..	..	..	1.0	0.2	..	..	..	..	..	..	0.5	0.1	..	..	1	0.1	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	0.5	0.1	..	..	..	..	..	..	..	..	0.5	0.2	..	..	..	..	..	..	2.0	1.4	..	..	..	..	..	..
26.9	20.5	17.6	16.0	21.9	9.0	15.6	..	..	9.5	13.4	19.5	37.1	20.5	29.5	..	..	6.0	5.1	41.5	64.3	63	250.0	168	140.0	1	0.1
..	0.5	0.1	..	..	1.0	1.0	..	..	..	..	2.5	1.0	0.5	0.3	..	..	0.5	0.1	0.5	1.1	..	..	2	1.2	..	..
..	..	..	0.5	0.1	4.0	0.1	..	..	0.5	0.1	13.5	0.4	1.0	0.1	..	..	10.5	0.2	0.5	0.1	1	0.2	..	..	..	..
..	..	..	5.0	0.1	27.5	0.5	..	..	..	..	67.5	0.9	..	..	..	..	58.0	1.1	..	..	..	..	9	0.1	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	0.5	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	0.1	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	0.5	0.1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0.5	0.1	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	0.1
0.2	3.5	0.2	3.0	0.2	0.5	0.1	..	..	2.5	0.1	1.5	0.1	1.5	0.2	..	..	2.5	0.2	2.5	0.3	4	0.5	6	0.5	..	..
..	..	..	..	..	0.5	0.1	..	..	..	..	..	..	0.5	0.1	..	..	..	..	..	..	1	0.1	..	..	..	..
..	0.5	0.1	0.5	0.1	0.5	0.1	..	..	0.5	0.1	5.0	0.2	0.5	0.1	..	..	..	..	1.5	0.2	..	..	1	0.1	..	..
..	..	..	1.0	0.1	0.5	0.1	..	..	0.5	0.1	2.0	0.1	..	..	..	..	1.0	0.1	1.0	0.1	..	..	1	0.1	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	27.0	..	30.0	..	49.5	..	0.5	..	14.5	..	115.5	..	24.5	..	0	..	79.5	..	57.0	..	69	..	191	..	6	..
27.7	..	18.6	..	23.8	..	18.6	..	0.1	..	13.9	..	40.9	..	30.3	..	0	..	7.2	..	68.7	..	250.8	..	142 8	..	0.4
7	6.6		3.8		2.6		0.1		1.9		4.9		1.3		. 0		3.2		7.7		0.8		12.8		0.4	

Clay, stones, some fresh Zostera

Ler, Grus, Sten, frisk Zostera
Clay, gravel, stones, fresh Zostera

Sand, Grus, frisk Zostera
Sand, gravel, fresh Zostera

Sand med Zostera
Sand with Zostera

Sand med stærkt stinkende Mudder
Sand with very fetid mud

Sand og Dødtang
Sand and dead weed

Sand

Sand og Grus, frisk og død Zostera
Sand and gravel, fresh and dead Zostera

Sand og Sten, noget stinkende
Sand and stones, somewhat fetid

Sand med Zostera
Sand with Zostera

Intet Bundmateriale
No Bottom material

Mørkt, noget stinkende Sand med frisk Zostera
Dark, somewhat fetid sand with fresh Zostera

Sand og Grus
Sand and gravel

Tabel 2. Stationer med Bundprøver, opgrave
Antal og Raavægt a
Table 2. Stations of Bottom Samples, du
Number and Rough Weight of t

Station Nr.	81		82		83		84		85		86		87	
A. = Antal, V. = Raavægt i g A. = *Number*, V. = *Rough Weight in g.*	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.
Mya arenaria	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Mytilus edulis	..	..	..	..	2	2.8	..	..	..	..	..	..	..	..
Hydrobia ulvæ	..	..	..	..	7	0.1	..	..	..	..	..	..	..	..
Nereis diversicolor	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Scoloplos armiger	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Corophium sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Antal *Number*	0	..	0	..	9	..	0	..	0	..	0	..	0	..
Raavægt *Rough Weight*	..	0	..	0	..	2.9	..	0	..	0	..	0	..	0
Fiskeføde, Raavægt i g pr. 0.1 m² *Fish Food, Rough Weight in g per 0.1 sq.m.*	0		0		0.9		0		0		0		0	
Bundart *Nature of Bottom*	Stinkende Sand og Mudder, lidt Smaasten *Fetid sand and mud, a little pebbles*		Stinkende grøft Grus, Sand og lidt Mudder *Fetid, coarse gravel, sand and a little mud*		Stinkende Sand og Mudder *Fetid sand and mud*		Stinkende groft Grus og Sand, lidt Sten, Mudder *Fetid coarse gravel and sand, a few stones, mud*		Stinkende Sand og Mudder *Fetid sand and mud*		Stinkende Sand og Mudder, enkelte Sten *Fetid sand and mud, some few stones*		Stinkende Sand, grøft Grus, Sten (c. 1 l) Mudder *Fetid sand, coarse gravel, stones (c. 1 l.) mud*	

kker, hver paa 0.1 m². Oktbr. 1931.
dyrene i g pr. 0.1 m².
Diver, each of 0.1 sq.m. Octbr. 1931.
Animals in g per 0.1 sq.m.

89		90		91		92		93		94		95		96		97		98		
V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.
..	..	..	..	..	..	..	..	..	..	..	..	..	10	0.5	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	6	0.1	5	0.1	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	113	5.2	3	0.4	..	..	2	0.2
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	15	0.6	2	0.2
..	..	..	..	..	..	..	..	..	..	..	..	..	1	0.1	..	..	..	..	..	..
..	0	..	0	..	0	..	0	..	0	..	0	..	130	..	8	..	15	..	4	..
0	..	0	..	0	..	0	..	0	..	0	..	0	..	5.9	..	0.5	..	0.6	..	0.4
	0		**0**		**0**		**0**		**0**		**0**		**5.9**		**0.5**		**0.6**		**0.4**	
	Stinkende sort Dynd og Sand *Fetid black ooze and sand*		Stinkende gult Sand og lidt Mudder, lidt Smaasten *Fetid yellow sand and a little mud and pebbles*		Stinkende Sand og Mudder, enkelte Smaasten *Fetid sand and mud, a few pebbles*		Stinkende gult Sand og Mudder, raaddent Træ, lidt Smaasten *Fetid, yellow sand and mud, decayed wood, a little pebbles*		Stinkende Sand og Mudder, lidt Smaasten og Slagger *Fetid sand and mud, a little pebbles and cinders*		Stinkende Sand og Mudder, en Del Smaasten *Fetid sand and mud, some pebbles*		Sand og lidt Mudder, kun lidet stinkende *Sand and a little mud, only little fetid*		Stinkende Sand, Ler og Mudder, lidt Sten *Fetid sand, clay and mud, a little pebbles*		Dødtang og noget Mudder, (c. 2 l) *Dead weed and some mud (c. 2 l.)*		Stinkende Sand, lidt Sten og Mudder *Fetid sand, a few stones and mud*	

Summary.

Bottom sampling with a Petersen Grab of 0.1 sq.m., supplemented with bottom samples taken by a diver, at the outfalls of drains at Copenhagen and Gentofte in May and October, 1931, showed the following conditions.

1. At the main pipe of the Kløvermarksvej (Fig. 2) was found an area of abt. 200 m. to both sides of the outfall with no animal life. Another much larger area showed signs of pollution, the bottom being fetid and containing sulphuretted hydrogen, but nevertheless there was a rich animal life, especially in certain localities. Outside these areas neither bottom nor animal life showed any traces of pollution.

2. At the drains of Svanemøllebugten (I and II in Fig. 3) was found a comparatively large area (abt. 300 × 600 m.), including the outfalls of both drains, with no animal life. At the drains off Tuborg Harbour, Hellerup Harbour, and Charlottenlund (III, IV, and V, respectively, in Fig. 3) only the close vicinity of the outfalls had no bottom fauna.

3. At the drains at Klampenborg, Taarbæk, and Strandmøllen (I, II, and III, respectively, in Fig. 4) bottom animals were found at all stations even close to the outfalls.

Thus we see that a pollution of the bottom injurious to the bottom fauna takes place only within a comparatively small area with a radius of 100—200 m., round the outfalls of the drains. Outside this area the quantity of bottom animals and of fish food is of a size, which corresponds fully to what is found at similar places in non-polluted water.

II.

Hydrographical Investigations of the Pollution of the Sound at Copenhagen.

By

AAGE J. C. JENSEN

In order to examine to which extent the sewage pollution at Copenhagen influences the character of the water in a way so as to trouble animal life, investigations of the hydrographical conditions in the Sound off Copenhagen were made on May, 6th—11th, and on Sept., 23rd, 1931.

The investigation included determinations of temperature, salinity, and oxygen content. The main investigation in May was made from the steamer of the Danish Biological Station "Japetus Steenstrup". The supplementary investigation in September was made from a motor-boat which was most kindly put at our disposal from the Office of the Commissioner of Public Works by Messrs. A. Bjerre, City Engineer and Surveyor, and A. E. Lund and Joh. Funck, Branch Engineers. Salinity and oxygen content were determined by titration at the Hydrographical Laboratory of Kommissionen for Danmarks Fiskeri- og Havundersøgelser (Professor Martin Knudsen).

The results of the observations are shown in the below Tables and the situation of the stations is given on the Charts, Fig. 1—4 in paper I of this report (H. Blegvad: Investigations of the Bottom Fauna at Outfalls of Drains in the Sound).

Conditions of Weather and Current During the Investigation.[1]

Conditions of weather and current play a considerable part in an investigation of the water pollution, partly because the pollution is more conspicuous by calm weather, partly because the current determines the direction in which the polluted water tends to drift.

During the investigation in May weather conditions were as follows, according to observations on the Drogden Lightship (Nautisk-meteorologisk Aarbog).

Date	Temperature			Wind Conditions	Cover of Clouds
	Mean	Max.	Min.	8 a.m.—8 p.m.	8 a.m.—8 p.m.
May, 6th.	9.1	12.7	5.4	Calm or slight winds from ESE.	2—3
- 7th	8.7	11.1	6.8	Wind ENE Force 3—4	6—10
- 8th	9.9	13.4	7.0	Slight, changing winds or calm	2—10
- 11th	7.2	9.9	6.3	Wind SSE. Force 2—3	10

During the investigation of the pollution at the largest drain of Copenhagen, the Kløvermarksvej Drain, and the large drains in Svanemøllebugten together with the drains to the north of this place up to Klampenborg, carried out on May, 6th—8th, conditions of weather and current made the pollution very conspicuous, weather

on the first and third day being chiefly calm, while on the second day slight to fresh easterly winds kept the polluted water close to the shore.

On all days of investigation current was slow. At Drogden on May, 6th, it was southerly for about 12 hours, the rapidity being only 0.2—0.5 nautical miles per hour; on the other days it was northerly with a maximum rapidity of 0.7 nautical mile per hour, otherwise only 0.2—0.5 nautical miles per hour.

Investigation of Kongedybet, Svanemøllebugten, and the area between the Tuborg Harbour and Klampenborg.

Salinity.

The variation of the salinity with the depth is shown in Fig. 1. It is seen that the upper water layer, which consists of outflowing Baltic water with a salinity of about 7.7—8.8 pro mille, was a little thinner on the 7th than on the 6th of May, the *discontinuity layer*, which separates it from the bottom layer, being found at a depth of about 10 m. on May, 6th, but at a depth of about 8 m. on May, 7th. In the bottom layer was found water with a salinity of up to 25 pro mille at depths of 12—13 m. The distribution of salinity was nearly like the normal one found in calm periods. The resultant current of the surface layer has a northerly direction, whereas at the bottom it is southerly as far southwards in the Sound as Middelgrunden[1]).

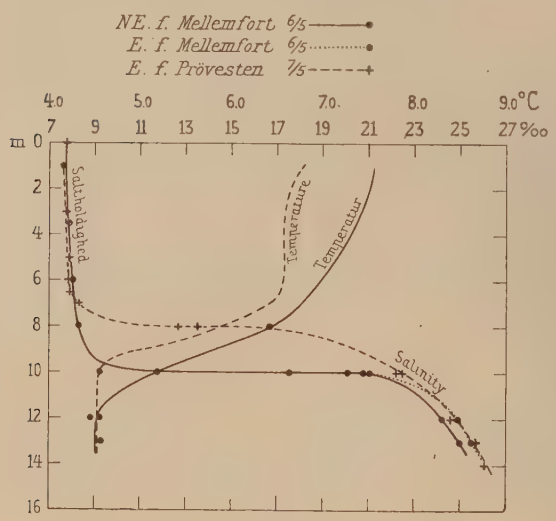

Fig. 1.

Generally, however, the current at the bottom is so slow, that the water below the discontinuity layer may be considered stagnant. During periods of rough weather the bottom layer and the surface layer will mix, and the discontinuity layer will be found at greater depths. Thus on Sept., 23rd, the separation against the salter bottom layer was not met with until at a depth of 14—15 m.

The salinity of all the water samples taken at the outfalls of drains was only a little lower than that of samples taken at some distance in pure water. In this connexion, however, it should be remembered that the salinity of all the water samples was calculated from determinations of the content of chlorine, or rather the halogen content, by means of Professor Martin Knudsen's "Hydrographical Tables".

[1]) J. P. Jacobsen: Die Wasserumsetzung durch den Öresund, den grossen und den kleinen Belt. — Medd. f. Komm. f. Havunders. Ser. Hydrografi Bd. II. Nr. 9. 1925.

Generally this can hardly be justified for samples of water that have been materially intermixed with sewage water because here the proportion between the quantity of chlorine and the other elementary substances is hardly constant and at any rate is hardly of the same value as in sea-water. As the reduction of the chlorine content by the admixture of sewage water, which in comparison with the Sound water is not very saliferous, was small even in the most polluted water, the error made in calculating the salinity from the quantity of chlorine will be rather insignificant. It would of course be absurd to calculate the total amount of salt in the sewage water from the content of chlorine by using the same coefficient as is used for the sea-water.

A good deal of the determinations of the quantity of chlorine occurring as chlorides in the sewage water having been made by the same method as is used for the determination of the chlorine content of the sea-water, we have in the reduction of the amount of chlorine in the sea-water arising from the admixture with sewage water a reliable measure of the percentage admixture of sewage water.

According to an individual determination by Dr. E. Bondo, the sewage water at the pumping station of the Kløvermarksvej contained a quantity of chlorine of 420 mgs. per liter[1]), and according to some determinations of the quantity of chlorine in the feeder of the sewage disposal works at the Trekronergade made by K. P. Rehof, C. E., of the Office of the Commissioner of Public Works, the quantity of chlorine averaged 473 mgs. per liter or 0.47 pro mille.

Immediately above the outfall of a drain where the sewage water rises to the surface the intermixing of the sewage water with the sea-water is very incomplete, so that by calm weather the water fouled by fæces is seen like clouds in the water. At a short distance and always less than 50 m. from the outfall the intermixing is so far advanced that in ordinary areometer measurings it is impossible to point out any difference in samples taken within a few metres of each other. At a distance of 50 m. from the outfall at the Kløvermarksvej the streak of sewage water is generally at least 50 m. in breadth.

In the sampling of the water at the outfalls of the drains were chosen the places where the water seemed to be most polluted. In spite of this the quantity of chlorine found in each of these samples was only a little below the one found in the clear water at some distance from the outfall. The same conditions were found by E. Bondo in his investigations of 1922 and 1923[1]).

The lowest quantity of chlorine at the outfall of the Kløvermarksvej drain was 4.15 pro mille which corresponds to a (calculated) salinity of 7.15 pro mille, while at the same time (May, 6th) the quantity of chlorine 100 m. to the south of this place was 4.26 pro mille (salinity 7.72 pro mille), and the sewage water was drifting in a N.W. direction. The lowest chlorine content observed on May, 6th, in Kongedybet outside the area of the polluted water was 4.19 pro mille (salinity 7.59 pro mille), found at a depth of 1 m. at the north-easternmost station (see Fig. 2, p. 7).

[1]) Erik Bondo: Om Colibakterien. — København 1924, p. 188.
[2]) E. Bondo, l. cit. 1924, p. 186.

For the rest the chlorine content at these stations ranged between 4.26 and 4.27 pro mille (salinity between 7.68 and 7.74 pro mille) at the surface, the mean value being 4.27 pro mille. Supposing the sewage water is intermixed with surface water only (which, as mentioned, was not the case) the admixture of sewage water would be $\frac{100\,(4.27 - 4.15)}{4.15 - 0.47}$ = about 3 per cent. in the most polluted water observed.

However, the sewage water rising to the surface is mixed with the lower water layers, and if we take the chlorine content of the polluted water at a depth of about 5 m., i. e. 4.41 pro mille, as the average value of the water with which the sewage water is mixed, the admixture of sewage water in the water sample examined will be 7 per cent.

In the supplementary investigation, on Sept., 23rd, a water sample was taken about 50 m. from the outfall of the Kløvermarksvej Drain in the middle of the sharply delimitated streak of highly polluted water. At this distance from the outfall the mixing was apparently complete. The chlorine content was here 4.21 pro mille, corresponding to a salinity of 7.63 pro mille, while the salinity of 2 surface samples taken at the same time in Kongedybet outside the area of polluted water, was respectively 7.90 and 7.90 pro mille at the surface, and 7.92 and 7.95 pro mille at a depth of 5 m. The average quantity of chlorine in clear water may consequently be put at 4.4 pro mille, and then we find the admixture of sewage water in this sample to be about 4 per cent.

According to calculations made by K. P. Rehof, C. E.[1]) about 117 000 m^3 of sewage water are emptied into the Sound during 24 hours. This corresponds to a quantity of about 1.4 m^3 a second. However, the quantity of sewage water varies in the course of the day, and from about 11 a.m. to about 5 p.m., the time within which the investigation was made, it was about 2 m^3 a second. If we put the average admixture of sewage water at 4 per cent. at a distance of 50 m. from the outfall, the quantity of sewage water pumped out in 1 second has here been mixed up with 50 m^3 of pure Sound water. The depth of the outfall is about 10 m., and supposing the clear Sound water flows to the intermixing area in a breadth of 50 m., the rate of drift of the Sound water must be about 0.2 naut. miles an hour to bring about this degree of thinning. This is a slow rate for the current through Kongedybet. At Drogden the rapidity of current averages 0.9 miles per hour, calculated from the Nautisk-meteorologisk Aarbog. The rate of current between Amager and Middelgrunden cannot be supposed to be much less, the breadth of the moving body of water not being much larger for a cross-section from the Kløvermarksvej Drain across Middelgrunden and Saltholm to Limhamn than for a cross-section from Dragør across Drogden to the nearest point on the eastern side of the Sound (Klagshamn).

Hence the thinning will generally be still greater than the one observed in the investigation.

In Svanemøllebugten the lowest quantity of chlorine observed was 4.21 pro mille, corresponding to a salinity of 7.59 pro mille (May, 7th), which means an admixture

[1]) For this information I am indebted to Mr. A. Bjerre, City Engineer and Surveyor.

of sewage water of at any rate less than 5 per cent. A total of 11 water samples were taken within the area of polluted water, 4 of which were taken immediately at the outfalls.

From the reservoirs at Scherfigsvej and Svanemøllen is emptied a total of about 12 600 m^3 of sewage water during 24 hours, while the quantity of water found in Svanemøllebugten up to a line from the Petrol Harbour to the pier of Tuborg (Lautrup) Harbour is about 150 times as large.

In a surface sample taken immediately at the outfall of the drain off Hellerup Yacht Harbour on May, 8th, was found 3.90 pro mille of chlorine (7.03 pro mille of salt), and the quantity of chlorine in a water sample taken on the same day in pure water 100 m. in a N.E. direction from this place being 4.46 pro mille (salinity 8.04 pro mille) at a depth of 1 m. (surface sample missing), this means an admixture of 10 per cent. of sewage water at the highest. At the time when the investigation was made the pollution was concentrated in a very small area, weather being calm and current slow.

In all other investigations of the content of chlorine of the water near the outfall of the drain the quantity of chlorine was found to be much less reduced and consequently the admixture of sewage water was much less than in the water samples mentioned here.

Thus the investigation shows that already at the outfall of the drain the sewage water is highly mixed up with Sound water.

Temperature.

The variation of the temperature with the depth in Kongedybet is seen in Fig. 1. At the stations nearest to the shore the surface temperature was higher, thus on May, 7th, at a station N. of Mellemfortet 8.68° C., at the Sundby District 3 at a depth of 2 m. even 10.31° C., in Svanemøllebugten between 8.85° and 10.40° C., and along the coast between Tuborg Harbour and Skodsborg at depths of 0—4.5 m. it was between abt. 9° and abt. 11° C. These temperatures of 9°—11° C. correspond closely to what was found at the same time at the coasts of other Danish waters (cp. Nautisk-meteorologisk Aarbog, 1931).

The temperature of the bottom layer is the same as was found at the same time at Lappegrunden, Schultz Grund, and Anholt Knob at a depth of 15—16 m., i.e. below the discontinuity layer.

Content of Oxygen.

The variation of the oxygen content with the salinity is shown in Fig. 2. The dots denote observations from Kongedybet at a distance of not less than 100 m. from the outfalls of the drains. The Fig. shows that the surface layer, the salinity of which is 7.7—8.5 pro mille, has an oxygen content of above 7.9 c.c. and up to 8.9 c.c. per liter. The oxygen content of the discontinuity layer was little lower and practically uniform till the bottom layer began at a salinity of 23 pro mille. In the bottom layer the oxygen content decreased with an increasing salinity, and

the lowest value observed was 4.18 c.c. per liter at a salinity of 26.08 pro mille and 4.54° C. at a depth of 14 m. The low oxygen content in the bottom layer is made the object of a closer mention below.

The degree of saturation (see Fig. 3) of the surface layer and the discontinuity layer was high at all these stations, at most of them a little more than 100 per cent., and at one station at a depth of $3^1/_2$ m. it even reached 112.9 per cent. As a rule the degree of saturation is highest in the warmest water, i.e. along the coast, because she heating of the water causes a decrease of the oxygen content necessary for the taturation. The percentages of saturation found at the said stations are compared in the below Table.

Table. 1. Percentages of saturation observed in Kongedybet at a distance of not less than 100 m. from the outfalls of the drains.

Depth in metres	May, 6th, 1931	May, 7th, 1931
0	103.4, 106.6	100.1, 100.6, 101.5, 102.1
1	..	..
2	..	..
3	..	101.0, 101.0, 101.2
4	100.5, 112.9[1])	..
5	..	98.4, 102.4
6	101.1, 101.4	102.3, 99.0[1])
7	101.8	101.7, 101.9[1])
8	100.2	97.9, 96.5[1]), 100.6[1])
9	..	..
10	99.5, 101.0	97.9
11	..	..
12	69.1	..
13	61.0, 74.1	..
14	..	55.2

The other signatures in Figs. 2 and 3 show observations from the outfall of the Kløvermarksvej Drain, from Svanemøllebugten and from the drains between Tuborg Harbour and Klampenborg.

It is seen that several of them show a considerable subsaturation.

It should be noted that the determination of oxygen content by Winkler's method does give quite exact values when nitrites or organic matter are found in the water examined, for nitrites will extricate iodine from potassium iodine, and the organic matter will bind the iodine, and thus we shall get either too high or too low a value, respectively, for the oxygen content.

However, the errors thus arising are only small, the more so as the thinning of the sewage water had proceeded far in all samples examined, and the effects of the two sources of errors will counteract each other.

[1]) These observations were made at depths 0.5 m. smaller than stated.

At the Kløvermarksvej Drain the oxygen content at surface in the most polluted water was only 5.25 c.c. per liter, and the degree of saturation 66.9 per cent.; few metres off, in water that was a little less polluted, the oxygen content was 6.46 c.c. per liter and the degree of saturation 82.3 per cent. At a depth of $2^1/_2$ metres were found 7.46 c.c. of oxygen per liter and a saturation percentage of 93.8, and at a depth of 5 metres 6.88 c.c. of oxygen and a saturation degree of 99.6.

In the investigation on Sept., 23rd, was found 5.97 c.c. of oxygen per liter, i.e. a saturation of 83.5 per cent., at the surface of polluted water 50 metres from the outfall of the drain.

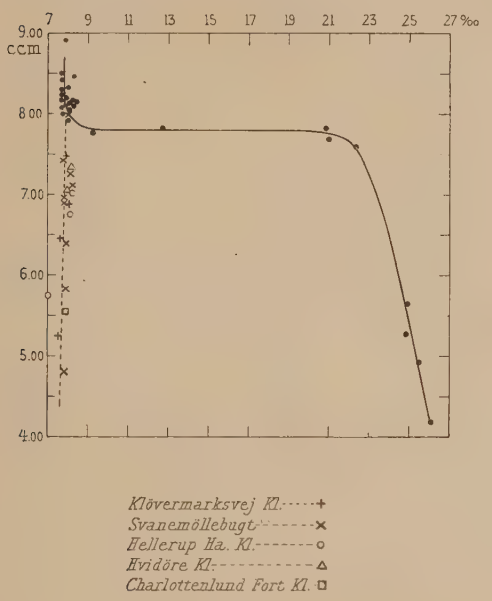

Fig. 2.

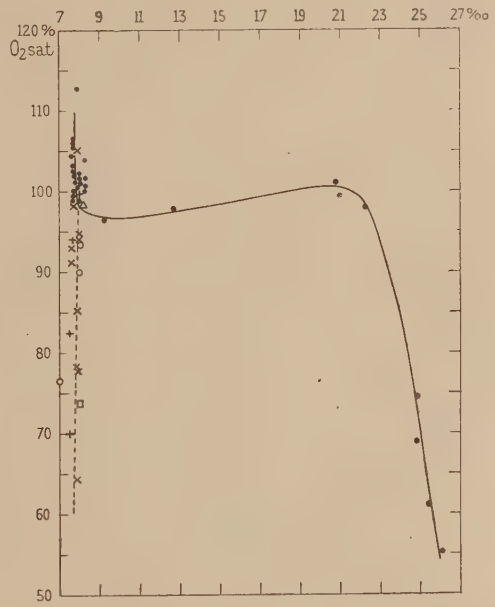

Fig. 3.

At the drain Sundby District III there was no drainage during the investigation, and at depths of 0 and 2 metres the oxygen content was respectively 8.00 and 7.83 pro mille, the degree of saturation being respectively 105.7 and 105.8 per cent.

In Svanemøllebugten there was on May, 6th, only a small subsaturation in spite of the fact that 4 of the samples were taken in highly polluted water at the two outfalls. The lowest oxygen content, 6.39 c.c., corresponding to a saturation degree of 85.3 per cent., was found at a depth of 3 m. at the northernmost outfall. At the outfalls there was at the surface 6.90 and 6.97 c.c. of oxygen, i.e. a saturation degree of respectively 91.0 and 92.8 per cent. At a distance of 100 m. to seaward of the outfall in distinctly polluted water the oxygen content was 7.97 c.c. at the surface (saturation 105.4 per cent.), and at depths of $3^1/_2$ and 4 m., respectively, 7.24 and 10 c.c., i.e. a saturation degree of respectively 94.8 and 93.9 per cent.

On May, 7th, however, when oxygen determinations were made at 3 stations

to the W. of the outfalls the investigation showed a considerable subsaturation, viz. at a depth of 1 m. respectively 4.81, 5.82, and 5.81 c.c., or respectively 64.3, 77.8, and 78.2 per cent.

The outfall off Hellerup Yacht Harbour. Determinations of oxygen content, made here, showed at the surface and at a depth of 3 m., respectively, 5.76 and 7.03 c.c. of oxygen, i.e. saturation degrees of 76.5 and 93.7 per cent., respectively. 100 m. to the N.N.E. at a depth of 1 m. in apparently pure water was found an oxygen content of 6.76 c.c., i.e. a saturation degree of 90.2 per cent.

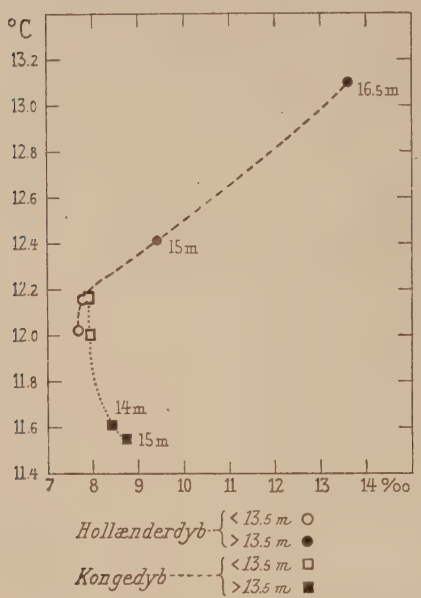

Fig. 4.

At the Hvidøre Drain at a depth of 1 m. was found an oxygen content of 7.04 c.c. (93.1 per cent.) and 100 m. to the N.W. in apparently pure water 7.36 c.c. (98.5 per cent.).

At the Charlottenlund Fort Drain at the surface was found 5.55 c.c. of oxygen, i.e. a saturation degree of c. 74 per cent.

The cause of the decreased oxygen content in the water at the outfalls is an oxygen consumption due to the pollution.

The vital consumption of oxygen, i.e. the consumption caused by bacteria and decaying organic matter is far greater in the polluted than in the pure water of the Sound, as has been demonstrated by E. Bondo[1]). However, his investigations were made at 20°—22° C. only, and so we cannot from these investigations determine the consumption of oxygen in nature. In the vital consumption of oxygen a considerable quantity is consumed by the aerobic organisms by oxygenation of organic and to some degree also of inorganic matter (esp. nitrites) in the sewage water soon after it has left the drain pipe and may absorb oxygen from the sea-water with which it is mixed up (and partly also from the air).

That the small quantity of oxygen found is not due directly to admixture of sewage water which is very poor in oxygen, appears from the fact that, as is shown by the salinity, the sewage water constitutes but few per cent. of the water samples, even where the smallest quantities of oxygen are found, and that the percentage reduction of the oxygen content is consequently far greater than the percentage reduction of the salinity.

The small oxygen content found in the bottom layer of Kongedybet during the investigations in May, might possibly be partially due to the fact that this water was somewhat polluted by mud from the sewage, which in this nearly stagnant water had time to reduce the content of oxygen considerably.

[1]) E. Bondo, l. cit. 1924, pp. 178 and 254.

In order to examine whether this be the case, an investigation of the oxygen content was made on Sept., 23rd, partly in Kongedybet, partly in Hollænderdybet.

The current of the upper water layer, both when northerly and when southerly, following the trend of Kongedybet, the possible pollution of the bottom water must be chiefly confined to Kongedybet, because mud from the drains might be carried to Hollænderdybet only by a change of current. It turned out in the investigation that so strong an intermixture of the water layers had taken place, that the salinity was nearly the same to a depth of about 13 m. But at a depth of 14 m. and deeper the water showed a somewhat higher salinity. In Fig. 4, where corresponding values of temperature and salinity are given for two stations, one of which is situated 1 km. S.E., the other about 2 km. S.W. of the Middelgrundsfort, it is seen that the bottom water in the two areas was widely different. The bottom water in Hollænderdybet showed an increasing temperature with increasing salinity, while the bottom water in Kongedybet showed a decreasing temperature with increasing salinity. Thus the bottom water of one of these areas is renewed by an inflow from the north later than that of the other, and on account of the depths of water in the northern parts of resp. Kongedybet and Hollænderdybet, we know for certain that the bottom water of the latter is renewed later than that of the former; for the bottom water of Hollænderdybet is directly connected with the bottom water of more northerly regions in the Sound, whereas the water of Kongedybet is separated from these regions by areas with a depth of only 12 m. An examination of the oxygen content shows that, given the same depth, it is nearly the same in Kongedybet and Hollænderdybet, and, if any difference, Hollænderdybet shows the lowest content. Thus, at a depth of 15 m. it was resp. 6.15 and 6.50 c.c. per liter, i.e. the degree of saturation was resp. 87.6 and 90.7 per cent. The same relation between the bottom water of Kongedybet and of Hollænderdybet was found at two stations situated in the close vicinity of either side of Middelgrunden E. of Prøvestenen (see Fig. 1, p. 6). Here the oxygen content in Hollænderdybet and Kongedybet at the bottom (depth 13 m.) was resp. 6.65 and 6.85 c.c. per liter, the percentages of saturation were resp. 93.5 and 95.0. Thus, in spite of the fact that the bottom water of Kongedybet has been more stagnant than that of Hollænderdybet, the oxygen content of the former has been not more, but rather less reduced than that of the latter, and so the sewage mud cannot be a contributory cause of the low oxygen content which may be found in the bottom water in the Sound off Copenhagen. This can only be attributed to the stagnation of the water.

The outfalls of drains at Taarbæk and Skodsborg.

The investigation was made on May, 11th, under rather unfavourable conditions: they had to be made from a boat, the outfalls being situated at depths of 3 m. at the highest, or at the shore-line; the wind was inshore and the sea was rough.

The following investigations were made.

At the drain south of Taarbæk Harbour with outfall at a depth of 3 m.

In distinct polluted water the salinity at the surface was 8.04 pro mille, the content of oxygen 7.03 c.c. per liter, and the saturation about 94 per cent.

At the drain south of Mølleaaen on the shore-line 5 m. from the outfall in distinctly polluted water the salinity at the surface was 3.30 pro mille, the oxygen content 7.92 c.c. per liter, and the saturation about 100 per cent.

10 m. from the outfall in apparently pure water the surface salinity was 7.59 pro mille.

At the outfall off Skodsborg Sanatorium in distinctly polluted water the salinity was 7.81 pro mille, the oxygen content 7.61 c.c. per liter, and saturation about 100 per cent. at the surface.

Under the conditions mentioned it was impossible to find the three northerly outfalls. Here the pollution evidently was but slight.

400 m. from the shore the salinity was 8.04 pro mille at the surface and 8.15 at the bottom (depth 5 m.). The oxygen content was resp. 7.50 and 8.09 c.c., and the degrees of saturation resp. 105.8 and 102.8 per cent.

Summary.

The pollution of the water in the area from Taarbæk to Skodsborg on May, 11th, had only a very inconsiderable influence on the oxygen content of the water, and even on warm days by calm weather and slow current it will hardly be able to reduce the oxygen content in a way so as to injure animal life. But in the areas south of Klampenborg and especially in Svanemøllebugten and at the Kløvermarksvej Drain the consumption of oxygen was so great that on warm summer days under the same conditions as in the investigation, i.e. by calm weather or a slight sea wind and a slow current, the oxygen content may be reduced to such a degree that it will be injurious to animal life. Even if, in brief periods, the oxygen content sinks very much, we know from other areas that are sometimes very poor in oxygen that this will not be fatal to most of the bottom invertebrates, and during such periods the fish will only avoid these areas.

It turned out during the investigation that when the bottom water of Kongedybet is stagnant, it may have a very small content of oxygen. This is not caused by a conveyance to the area of sewage mud, but only by the natural consumption of oxygen in the stagnant water. The deepest outfall of a drain, the Kløvermarksvej Drain, is now found at a depth of about 10 m. In the existing state of things the rising sewage water will at once mix with the surface water, and at any rate it influences the oxygen content of the bottom water to a slight degree only.

Whether a conveyance of sewage water to the bottom layer will cause so great a consumption of oxygen in this water, which at times is as yet comparatively poor in oxygen, that the bottom fauna will decrease in quantity and producing power, is a different question which, on occasion, should be carefully considered.

m	t°C	S‰	O_2 ccm	$100\frac{O_2}{O_2'}$
6.-V.-1931				
St. 1. 55°40′.83 N.			12°38′.74 E.	
0	7.17	7.72	8.24	103.4
4	7.17	7.85	8.01	100.5
7	6.94	7.99	8.12	101.8
St. 2. 55°40′.88 N.			12°38′.02 E.	
0	7.78	7.52	5.25	66.9
0	7.78	7.59	6.46	82.3
2.5	7.32	7.68	7.46	93.8
5	7.10	7.94	6.88	99.6
St. 6. 55°41′.09 N.			12°39′.30 E.	
0	6.84	7.70	8.49	105.6
4	6.83	7.67	8.43	104.6
8	6.30	8.37	8.46	104.1
St. 8. 55°41′.23 N.			12°39′.07 E.	
0	6.71	7.74	..	..
6	6.80	7.95	..	..
8	6.44	8.22	8.11	100.2
10	5.00	20.81	7.83	101.0
12	4.56	24.90	5.27	69.1
St. 10. 55°41′.17 N.			12°38′.48 E.	
10	4.99	21.00	7.70	99.5
13	4.53	25.43	4.94	61.0
St. 11. 55°41′.16 N.			12°38′.33 E.	
0	7.20	7.68	..	..
6	6.91	7.95	8.12	101.4
St. 12. 55°41′.37 N.			12°37′.96 E.	
0	8.68	7.70	8.24	106.6
3.5	7.50	7.90	8.92	112.9
St. 14. 55°41′.44 N.			12°38′.30 E.	
6	7.12	8.03	8.06	101.1
10	5.20	20.08	..	..
13	4.57	24.94	5.65	74.1
St. 15. 55°41′.46 N.			12°38′.61 E.	
1	7.41	7.71	..	..
St. 16. 55°41′.49 N.			12°38′.91 E.	
8	6.59	8.26	..	..
10	5.21	17.47	..	..
12	4.46	24.25	..	..
6.-V.-1931				
St. 17. 55°41′.51 N.			12°39′.12 E.	
1	7.58	7.59	..	..
6	6.68	8.04	..	..
St. 18. 55°43′.16 N.			12°35′.84 E.	
0	9.29	7.65	6.90	91.0
3	9.46	7.65	7.42	98.3
St. 19. 55°43′.19 N.			12°35′.90 E.	
0	9.70	7.90	..	..
0	9.45	..	7.97	105.4
3.5	8.85	8.04	7.24	94.8
St. 20. 55°43′.29 N.			12°35′.77 E.	
0	9.68	7.59	6.97	92.8
3	9.41	7.95	6.39	85.3
St. 21. 55°43′.29 N.			12°35′.91 E.	
0	9.40	7.97	..	..
4	9.16	8.04	7.10	93.9
7.-V.-1931.				
St. 22. 55°39′.46 N.			12°38′.96 E.	
0	9.71	7.72	8.00	105.7
2	10.31	7.79	7.83	105.8
St. 23. 55°40′.24 N.			12°38′.68 E.	
0	7.41	7.68	8.00	100.1
5	7.2	7.68	8.16	102.4
St. 25. 55°40′.34 N.			12°39′.03 E.	
0	7.20	7.72	..	..
5	7.19	7.67	..	..
St. 26. 55°40′.40 N.			12°39′.20 E.	
0	7.74	7.70	..	..
5	..	7.70	..	..
7.5	6.81	9.18	7.77	96.5
St. 28. 55°40′.49 N.			12°39′.68 E.	
0	6.50	7.70	..	..
6	6.36	8.44	..	..
8	5.62	14.13	..	..
10	4.60	21.87	..	..
12	4.55	25.90	..	..
7.-V.-1931.				
St. 30. 55°40′.58 N.			12°40′.04 E.	
0	6.27	7.77	8.32	102.1
6	6.28	7.83	8.33	102.3
St. 32. 55°40′.80 N.			12°39′.53 E.	
0	7.14	7.74	..	..
8	5.94	13.53	..	..
10	4.61	22.23	7.59	97.9
12	4.60	24.63	..	..
14	4.54	26.08	4.18	55.2
St. 34. 55°40′.73 N.			12°39′.20 E.	
0	6.98	7.74	..	..
6	6.56	7.88	..	..
8	5.87	12.68	7.82	97.9
10	4.50	22.52	..	..
13	4.52	25.61	..	..
St. 35. 55°40′.69 N.			12°38′.98 E.	
0	6.64	7.86	..	..
5	6.53	7.95	7.95	98.4
7	6.40	8.30	8.16	101.7
St. 37. 55°40′.63 N.			12°38′.67 E.	
0	6.66	7.79	..	..
3	6.63	7.81	8.22	101.9
6.5	6.59	7.92	..	..
St. 38. 55°40′.92 N.			12°38′.62 E.	
0	7.20	7.72	8.08	101.5
3	7.17	7.72	8.15	101.0
7.5	6.40	8.28	8.15	100.6
St. 40. 55°41′.06 N.			12°38′.29 E.	
3	6.74	7.83	8.13	101.0
5.5	6.80	7.81	7.96	99.0
St. 41. 55°41′.08 N.			12°38′.09 E.	
0	6.87	7.74	8.08	100.6
3	6.83	7.76	8.13	101.2
8.-V.-1931.				
St. 42. 55°43′.17 N.			12°35′.71 E.	
1	9.88	7.83	4.81	64.3
St. 43. 55°43′.17 N.			12°35′.58 E.	
1	9.87	7.99	5.82	77.8

m	$t°C$	$S‰$	O_2 ccm	$100\frac{O_2}{O_2'}$
8.-V.-1931.				
St. 44. 55°43′.23 N.		12°35′.68 E.		
1	10.10	7.95	5.81	78.2
St. 45. 55°43′.37 N.		12°35′.73 E.		
1	10.10	..	..	..
St. 46. 55°43′.46 N.		12°35′.70 E.		
1	10.40	..	..	..
St. 47. 55°43′.56 N.		12°35′.65 E.		
1	10.01	..	..	..
4	9.63	..	..	..
St. 48. 55°43′.26 N.		12°36′.14 E.		
1	9.51	7.95	..	..
5	9.00	8.01	..	..
St. 49. 55°43′.24 N.		12°36′.42 E.		
1	8.50	..	..	..
3	8.33	..	..	..
5	8.16	7.99	..	..
St. 50. 55°43′.22 N.		12°36′.79 E.		
1	7.88	7.90	..	..
3	7.63	..	..	..
5	7.59	7.90	..	..
St. 51. 55°43′.65 N.		12°35′.86 E.		
1	9.83	..	..	..
3.5	9.85	..	..	..
St. 52. 55°43′.74 N.		12°35′.79 E.		
1	10.27	7.83	..	..
4	9.79	8.01	..	..
St. 53. 55°43′.75 N.		12°35′.93 E.		
1	9.78	..	..	..
5	9.61	..	..	..
St. 54. 55°43′.78 N.		12°36′.06 E.		
1	9.79	..	..	..
5	9.26	..	..	..
St. 55. 55°43′.84 N.		12°35′.86 E.		
1	9.77	..	..	..
5	9.42	..	..	..
St. 56. 55°43′.80 N.		12°35′.72 E.		
1	10.9	..	..	..
4.2	9.83	..	..	..

m	$t°C$	$S‰$	O_2 ccm	$100\frac{O_2}{O_2'}$
8.-V.-1931.				
St. 57. 55°43′.86 N.		12°35′.66 E.		
0	9.86	7.03	5.76	76.5
3	9.65	7.99	7.03	93.7
St. 58. 55°43′.96 N.		12°35′.69 E.		
1	9.80	8.04	6.76	90.2
3	9.31	..	..	..
St. 61. 55°46′.46 N.		12°36′.08 E.		
0	9.79	..	..	..
1	9.60	8.03	..	..
4.5	9.46	8.06	..	..
St. 62. 55°46′.52 N.		12°36′.00 E.		
0	9.42	..	..	..
1	9.41	7.83	7.04	93.1
4.5	9.11	8.12	..	..
St. 63. 55°46′.54 N.		12°36′.09 E.		
0	10.77	..	..	..
1	10.32	8.01	..	..
3	9.50	8.01	..	..
6	8.94	8.10	..	..
St. 64. 55°46′.57 N.		12°35′.92 E.		
0	10.30	..	..	..
1	9.90	8.04	7.36	98.5
4.5	9.22	8.06	..	..
St. 65. 55°44′.42 N.		12°35′.96 E.		
0	9.49	..	..	..
4.5	9.50	8.03	..	..
St. 66. 55°44′51. N.		12°35′.98 E.		
0	9.56	..	5.55	c. 74
3	9.47	7.94	5.55	..
St. 67 55.°44′.50 N.		12°36′.14 E.		
0	9.27	..	..	..
3	9.22	7.95	..	..
4.5	9.20	..	..	..
St. 68. 55°44′.60 N.		12°36′.00 E.		
1	9.29	..	..	..
3	9.32	..	..	..
11.-V.-1931.				
St. 69. 55°46′.97 N.		12°35′.90 E.		
0	..	8.04	7.03	c. 94

m	$t°C$	$S‰$	O_2 ccm	$100\frac{O_2}{O_2'}$
11.-V.-1931.				
St. 71. 55°48′.6 N.		12°35′.5 E.		
0	9.08	8.04	7.50	105.8
2	9.10	8.13	..	..
5	7.57	8.15	8.09	102.8
St. 72. 55°48′.46 N.		12°35′.26 E.		
0	..	3.30	7.92	c. 100
0	..	7.59	..	..
St. 73. 55°49′.5 N.		12°34′.8 E.		
0	..	7.81	7.61	c. 100
23.-IX.-1931.				
St. 74. 55°40′.91 N.		12°38′.69 E.		
0	12.03	7.63	5.97	83.5
St. 75. 55°41′.37 N.		12°38′.37 E.		
13	11.42	8.39	6.81	94.2
St. 76. 55°40′.81 N.		12°39′.58 E.		
0	12.20	7.90	6.69	94.1
5	12.12	7.95	6.74	96.1
13	11.48	8.35	6.85	95.0
St. 77. 55°40′.85 N.		12°41′.00 E.		
0	12.10	7.68	6.66	93.3
5	12.12	7.76	6.68	93.7
10	12.12	7.87	6.70	94.1
13	12.18	7.92	6.65	93.5
St. 78. 55°42′.60 N.		12°41′.00 E.		
0	12.02	7.65	6.72	94.0
10	12.16	7.88	6.58	92.5
13	12.16	7.90	6.59	92.7
15	12.41	9.39	6.15	87.6
16.5	13.10	13.64	4.60	68.0
St. 79. 55°43′.80 N.		12°40′.13 E.		
0	12.11	7.99	6.38	..
13	12.18	9.15	5.21	..
14	12.60	10.23	5.12	..
St. 80. 55°42′.53 N.		12°38′.35 E.		
0	12.16	7.90	6.70	94.2
5	12.00	7.92	6.71	94.0
14	11.60	8.42	6.73	93.7
15	11.55	8.71	6.50	90.7

III.

Analyses of Stock and Race of the Baltic Plaice During Recent Years.

By

ERIK M. POULSEN

Introduction.

Generally two different races of plaice are reported to occur in the Danish waters, the North Sea Race and the Baltic Race.

As spawning fish the North Sea race go through the Skagerak and far into the Northern and Eastern Kattegat, and at any rate as migrating fish they go far down into the Belts and into the Baltic. The Baltic race spawn in the southern Kattegat, the Belts, and in the Baltic as far as east of Bornholm.

On the basis of investigations made from 1893 to 1907 A. C. Johansen, 1929[1]), gives the following racial characters for the two races of plaice:

	North Sea Race	Baltic Race	Difference
Total number of vertebrae.....	abt. 43	abt. 42.3—42.7	abt. 0.5
— — - anal fin rays	abt. 54	abt. 50	abt. 4
— — - dorsal fin rays.....	72—73	67—68	abt. 5

A. C. Johansen further states that "The number of vertebrae and anal and dorsal fin rays decreases as we pass from the southern Kattegat down towards the southern part of the Belt Sea and the western Baltic, whereas it increases as we go east towards the Arcona and Bornholm Basins. These differences cannot be accounted for in every case by the fact that the supply of larvae and the immigration of young fish of the North Sea race are not equally great in the different areas."

During recent years the Dansk Biologisk Station and Kommissionen for Danmarks Fiskeri- og Havundersøgelser have collected further material to throw light on the biology of the plaice in the Baltic. On the basis of this material we shall in the following consider partly the distribution and number of individuals of the various age-groups, partly a series of race analyses for the purpose of giving a picture of conditions related to the renewal of the stock of plaice in the Baltic during the years in question.

1. The Composition in Age-groups of the Stock of Plaice in the Arcona Basin and in the Bornholm Deep with Adjacent Coastal Waters During the Years 1928—1931.

During recent years Danish fishing experiments have been made in the Baltic with the eel-tog from the "Japetus Steenstrup" during the summers of

[1]) A. C. Johansen: On some Characters of the Baltic Plaice which have changed during the last Decennaries. Rapp. et Proc. Verb. — Vol. LIV, 1929.

1928 and 1931, with the otter trawl from the "Dana" in the autumn of 1930, and Johansen's Young Fish Trawl along the coasts in 1927—31. Further, samples of commercial plaice have been examined. On the basis of these investigations a survey will be given in the following of the frequency of the different age-groups in different years.

Fishing experiments with Johansen's Young Fish Trawl have been made during the years 1927—31 at the coasts of the Baltic between Stevns (Seeland) and Hesnæs (Falster) and in the Køge Bugt. The following numbers of plaice of the 0-Group were taken per 30 minutes (number of stations in brackets):

Year	1927	1928	1929	1930	1931
0-Gr.	5 (16)	8 (16)	0.3 (17)	1.5 (13)	0.9 (14)

In proportion to the amount taken at the remaining Danish coasts, the catch of the 0-Gr. it very small at the coasts of the Baltic. During the years 1929, 1930 and 1931 there was thus — at the different Danish coasts — taken the following amount of the 0-Gr. per 30 minutes (number of stations in brackets):

Year	1929	1930	1931
The Skaw—Hals	35 (16)	16 (16)	30 (14)
Hals—Hasenøre—North. Seeland	4 (22)	10 (21)	1.2 (28)
Belt Sea	2 (51)	5 (52)	5 (41)
Gilbjerghoved-Aflandshage	0.4 (11)	10 (12)	1.4 (14)
Western Baltic	0.6 (7)	1.6 (7)	0.6 (5)
Aflandshage—Stevns	0.1 (8)	1 (6)	0.2 (6)
Stevns—Hesnæs	0.4 (9)	1.9 (7)	1.4 (8)
South. and East. coast of Scania[1])	0.9 (53)	0.4 (30)	..

It appears clearly from this table that the number of individuals of the 0-Group of plaice is much lower at the coasts of the western and the true Baltic with Køge Bugt than at any other place in our waters.

Besides the coastal investigations mentioned here a series of investigations with the trawl and the eel-tog in somewhat deeper water have been made during recent years. These investigations throw light on the distribution and frequency of both younger and older age-groups. In 1931 R. Kändler[2]) reports on investigations made in 1930 in the Oder Bank Area; he shows that on the Oder Bank and in the area round the Bank, chiefly inside the 20 m. curve, there is a considerable stock of young plaice belonging mainly to the II-Group. The 0-Group, however, was found in considerable quantities (in October) on the slopes of the Oder Bank in the direction

[1]) From Rapp. et Proc.-Verb. Transition Area (A. C. Johansen), Vol. LXVI (1930) and Vol. LXXIV, (1931).

[2]) Rudolf Kändler: Erneuerung und Nutzung des Schollen-Flunderbestandes im Gebiet der Oder Bank. Ber. d. deutschen wiss. Komm. f. Meeresunters. N. F. Bd. VI, H. 1. 1931.

of the Arcona Basin, whereas it was very small in numbers both on the Oder Bank and in the shallower water at the coast of Pomerania. The very few (9) individuals of the 0-Group caught on the Oder Bank and closer to the Pomeranian coast (at depths of 10—19 m.) had an average length of 9.1 cm (in October), whereas the 337 individuals of the 0-Group caught off the coast of Rügen outside the 20 m. curve averaged 6.3 cm. only. From this he concludes (as did A. C. Johansen too) that in the Baltic the home of the 0-Group plaice is not at the coast but in somewhat deeper water. Further he supposes that at an age of $^1/_2$—1 year its individuals migrate towards the coastal waters, especially onto the Oder Bank.

The Danish investigations in the Baltic during recent years show somewhat the same conditions. In Fig. 1 are put down the catches of the different age-groups of plaice in the eel-tog per 30 minutes in August 1928. As for the 0-Group also the catches in the push-net are given. It is seen that the 0-Group occurs in appreciable quantities both at the coast of Bornholm and in deeper water N.E. of Sassnitz. The I-Group occurs in considerable numbers on the Oder Bank and the slopes of the Bank. The II-Group is small in numbers anywhere (1926 is a poor year class). The III-Group shows a beginning dispersion; it is found both on the Oder Bank and in the Arcona Basin and also on the slopes towards the Bornholm Deep. Individuals of the IV-Group and older age-groups are not found on the Oder Bank, but occur in the Arcona Basin and on the slopes out towards the Bornholm Deep. In September 1930 a series of fishing experiments with the otter trawl (Fig. 2) were made from the "Dana" in the Oder Bank Area. The 0-Group occurs in smaller quantities in the deeper water near the N.E. coast of Rügen, but is rather more numerous in shallow water on the Oder Bank. The lengths of individuals of the 0-Group at various depths within this area are given in the below survey:

Fig. 1. Number of individuals of various age-groups of plaice caught in eel-tog per 30 minutes in Aug. 1928 in the true Baltic, together with catches of 0- and I-Groups in push-net (1 person in 1 h.) at Bornholm.

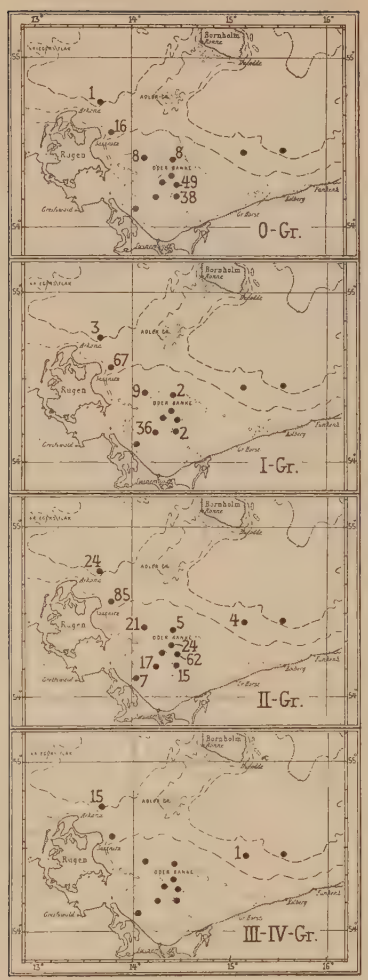

Fig. 2. Number of individuals of various age-groups of plaice caught per 60 minutes in otter trawl in the Oder Bank Area in Sept. 1930.

Depth in m.	40	21	13—16	6—10
Length in cms.				
5	2	..	..	..
6	1	5	1	3
7	1	10	1	16
8	..	1	3	40
9	..	..	6	25
10	..	..	..	3
Total number of individuals	4	16	11	87
Average length in cms.	5.75	6.75	8.27	8.10

It appears from the measurings that the smallest (and youngest) individuals were found in deeper water off the N.E. coast of Rügen and the larger (and older) individuals in shallower water on the Oder Bank. This suggests that as the 0-Group grows up it migrates towards the shallower water of the Oder Bank. The I- and II-Groups occur in large quantities on the Oder Bank and the slopes towards the deep water. The III- and IV-Groups were not at all caught on the Oder Bank or the slopes of the Bank but only at two stations in deeper water in the direction of the Arcona Basin and the Bornholm Deep. Individuals of older age-groups were not caught at all during these fishing experiments on the Oder Bank and the nearest surroundings.

In 1931 these waters were worked once more, some hauls with the eel-tog being made from the "Japetus Steenstrup" round Bornholm and at the Oder Bank (see Fig. 3). In these investigations no individuals of the 0-Group were caught. At the same time, however, some few experiments with the push-net and with Johansen's young fish trawl were made at the coasts of Bornholm, and one plaice of the 0-Group was caught at Balka (the eastern Bornholm). Otherwise the investigations with the eel-tog showed — in accordance with the fishing experiments of 1928 and 1930 — that the youngest year classes occur especially in the Oder Bank area and at the Rønne Bank, while the older ones are distributed over the deeper water of the Arcona Basin and the Bornholm Deep.

The investigations mentioned here show that the quantity of 0-Group plaice has changed very much from year to year, but in no year it has reached such numbers

of individuals as occur elsewhere in our waters. The investigations further showed that, at any rate in certain years, there is a comparatively dense stock of plaice of the 0-Group off the coasts of Rügen and on the Oder Bank. The I-Group may occur in rather considerable quantities on the Oder Bank, the Rønne Bank, and at the Danish and Swedish coasts of the Baltic. The II- and III-Groups have been found in large numbers on the Oder Bank and in somewhat smaller numbers on the Rønne Bank. The older mature individuals generally occur only in deeper water in the Arcona Basin and the Bornholm Deep.

As to the annual fluctuations in the frequency of the different year classes it turned out in the investigations that the 0-Group was comparatively numerous at the Danish coasts and at Bornholm in 1928; so the 1928-year class is a rich one. This is confirmed by the fact that comparatively many individuals of the I-Group were taken in the coastal investigations of 1929 at Denmark and Sweden (see Table 1, p. 50—51). However, the 1929-year class is poor. In 1930 the amount of 0-Group plaice was small both at the Danish and the Swedish coasts of the Baltic, but in the Oder Bank Area Danish as well as German investigations established the occurrence of a numerous 0-Group. In 1931 the quantity of plaice of the 0-Group was small at the Danish coasts of the Baltic and even very small at Bornholm. The investigations of the frequency of the older age-groups confirm the existence of the said changes in the number of individuals of the year classes. In 1930, e.g., there was a numerous stock of plaice of the II-Group (the 1928-year class) on the Oder Bank, whereas the I- and III-Groups (the year classes 1929 and 1927) were rather sparse. On the whole few plaice were taken during the investigations of 1931, the I-Group (the 1930-year class) being most numerous.

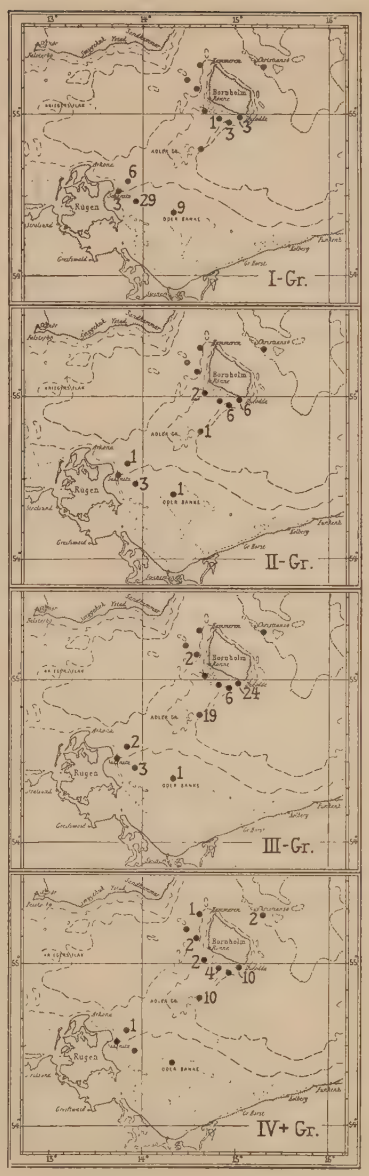

Fig. 3. Number of individuals of various age-groups of plaice caught per 30 minutes in Aug.-Sep. 1930 in the true Baltic.

H. Blegvad[1]) (1928) states that the year classes 1925 and 1927 in the Baltic

[1]) H. Blegvad: On the Influence of Fishery upon the Stock of Plaice in the Baltic proper. — Rapp. et Proc. Verb. Vol. XLVIII. 1928.

are comparatively rich, the 1925-year class being the richer one; the 1926-year class is poor.

Some analyses of commercial plaice caught in 1928 and 1931 confirm the results of the scientific experimental fishing. Samples of plaice caught at the Rønne Bank and E. of Nexø in the summer of 1928 gave the following numbers of individuals of the different year classes:

Group	II	III	IV	V	VI	VII+	Total
Year class.....	1926	1925	1924	1923	1922	1921 + older	
Number of individuals ...	2	88	41	96	17	24	268

Here, then, the year classes 1925 and 1923 are specially rich, while the year classes 1926 and 1924 are poor. H. Blegvad[1]) (1926) found that the 1923-year class was strongly represented in the Baltic in 1924 and 1925, the 1921-year class was rich as well, whereas the 1922-year class was poor.

A sample of 192 plaice caught E. of Nexø in January, 1931, showed the following distribution of age-groups and year classes:

Group	II	III	IV	V	VI	VII+
Year class.....	1928	1927	1926	1925	1924	1923 + older
Number of individuals	51	120	13	0	2	6

Hence the year classes 1927 and 1928 are strongly represented; very few individuals of the older year classes were taken and so nothing can be concluded as to their relative frequency.

Consequently, the analyses made during recent years show that in the Baltic the year classes 1921, 1923, 1925, 1927, 1928, and 1930 are comparatively rich, while those of 1922, 1924, 1926, 1929, and 1931 are poor. The question then arises: What is the cause of some year classes being rich and others poor?

H. Blegvad[2]) showed in 1927 that the good spawning years of the plaice of the Baltic coincides with high temperatures and salinities of the sea-water during winter and spring. In the case of the Belt Sea A. C. Johansen had already in 1915[3]) demonstrated a correspondence between rich spawning years and high surface salinities, and as to the Belt Sea and the southern Kattegat the same author in 1927 pointed out a similar correspondence through a long series of years between rich spawning years and high salinity and temperature of the surface water.

As to the Baltic during recent years I have in the below Table compared the salinity of the lower water layers at Drogden at depths of 5 and 8 m. and at Gedser

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[1]) H. Blegvad: On the Renewal of the Stock of Plaice in the Baltic Proper. — Rep. Danish Biol. Stat. XXXII, 1927.

[2]) H. Blegvad 1927, l. c.

[3]) A. C. Johansen: Fünfter Bericht über die Pleuronectiden in der Ostsee. — Rapp. et Proc. Verb. Vol. XXII. 1915.

Rev at depths of 10 and 15 m. in spring and early summer (April—July) with the number of individuals of the year classes. In consequence of the material concerning the numbers of individuals having been procured in different ways the quantities of course cannot be given in figures but may only be designated as modifications of rich (+) and poor (÷):

Year	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
Salinity in pro mille at Gedser Rev	13.7	11.5	12.8	9.7	12.8	11.4	11.1	12.4	11.7	12.0	11.4
Salinity in pro mille at Drogden	11.2	9.8	11.8	10.1	10.8	9.9	10.1	11.6	9.9	10.2	9.8
Amount of individuals	++	÷	++	÷	++	÷	+	++	÷	+	÷

The Table shows a distinct correspondence between high salinity in April—July and rich year classes and between low salinity and poor year classes. This connexion between high salinity and rich year classes may be determined partly by conditions in the Baltic being more favourable for the development of the plaice eggs spawned here in springs with high salinity, partly by the fact that in springs with comparatively salt water and consequently with an intense inflow from without considerable quantities of eggs and larvae are carried into the Baltic with the salt water. There is any reason to believe that such an inflow of larvae or eggs is at any rate a co-operant factor in the maintenance of the stock of plaice in the Baltic, because we know that the inflowing water may carry along large quantities of larvae, as, e.g., was the case with the inflow of salt water in 1923 which carried large amounts of haddock larvae from the Kattegat into the western Baltic, where during the following years they grew up in water of a considerably lower salinity than is ordinarily found on the nursery grounds of the haddock[1]).

The occurrence of rich and poor year classes of plaice in the Baltic proper may, however, also be due to a varying immigration of young plaice (the bottom-stage of the 0-Group, the I- and II-Groups). Such a theory of immigration was advanced by C. G. Joh. Petersen already in 1894[2]). The same year classes generally dominating both in the Kattegat and the Belt Sea as well as in the Baltic proper[3]) an immigration will contribute further towards the occurrence of rich and poor year classes. In the following — and chiefly on the basis of race analyses — we shall try to throw light on the question whether such an immigration has taken place during recent years.

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[1]) A. C. Johansen: On the Remarkable Quantities of Haddock in the Belt-Sea during the Winter of 1925—26, and Causes leading to the same: Journal du Conseil International pour l'Exploration de la mer. Vol. 1 No. 2. 1926.

[2]) C. G. Joh. Petersen: On the Biology of our Flat-fishes and on the Decrease of our Flatfish Fisheries. — Rep. Danish Biol. Stat. IV, 1894.

[3]) H. Blegvad, 1928, l. c.

2. On the Racial Characters of the Baltic Plaice, especially during Recent Years.

In Table A, p. 52—53, are put down a number of countings of vertebrae in plaice from various parts of the Danish waters, especially from the Baltic, caught in the years 1928—1931. The countings were made after a skeletonization of the fish by boiling.

In a sample from the Skaw the mean number of vertebrae is as high as 42.93 (86 individuals). From this place southwards in our waters it sinks gradually. North of Funen the number of vertebrae is 42.71 (186 individuals), and in the western Baltic where the lowest numbers of vertebrae are found, the mean number is 42.26 (304 individuals). From here into the Baltic the number rises once more. In the coastal waters E. of Møen and Falster it ranges between 42.55 and 42.75, the average being 42.62 (219 individuals). In the Arcona Basin the number of vertebrae is a little higher, the average of this area being 42.71 (108 individuals). For the Bornholm—Rügen Plateau the mean number is 42.73 (92 individuals). East of Bornholm the number is not less than 42,88 (275 ind.) or nearly as high as at the Skaw.

Hence, with regard to the changes in the number of vertebrae throughout our waters matters are nearly the same with the plaice as with the cod, the vertebrae of which, according to Johs. Schmidt (1930)[1]) increase in number again in the Baltic proper.

In Table B, p. 54—57, and in Fig. 4 is given a survey of the changes throughout our waters in the mean number of anal fin rays of plaice caught in the years 1922—1931.

In the North Sea, the Skagerak, and the north-western Kattegat the number of anal fin rays is high, 54.05 (1527 individuals). From this place southwards the number of rays decreases. N. of Funen it is 51.08 (922 individuals), in the western Baltic 50.65 (855 individuals), and in the coastal waters E. of Seeland, Møen, and Falster it is 50.55 (422 ind.). Farther into the Baltic again the number of rays is somewhat higher, 51.89 (133 ind.) in the Arcona Basin, and 51.74 (908 ind.) on the Rügen—Bornholm Plateau. E. of Bornholm, in the Bornholm Deep, it is somewhat lower again, viz. 50.95 (401 ind.).

The waters S. and E. of the Danish islands from Als to the southward of Ærø, Langeland, Lolland, and Falster to Møen thus is the home of a stock of plaice which is characterised by comparatively low numbers of vertebrae and anal fin rays. Farther into the Baltic, as shown by investigations during recent years, the number of fin rays and especially of vertebrae is higher; indeed, the vertebrae nearly reach the same number as in the northernmost part of the Kattegat; the rise in the number of fin rays is, however, considerably smaller. These facts go to show that the actual home of the Baltic plaice is the western Baltic and the adjacent parts of the Baltic proper, while in the Arcona Basin and in the waters round Bornholm and E. of

[1]) Johs. Schmidt: Racial Investigations. X. The Atlantic Cod (*Gadus callarias* L.) and local Races of the Same. — C. R. de Traveaux du Laboratoire Carlsberg, 18 vol., no. 6, 1930.

Rügen we have a stock of plaice with a number of anal fin rays that is a little higher, and a number of vertebrae that is a good deal higher.

The question then arises: Are these high numbers of vertebrae and rays due to an immigration from without (from the Kattegat), or are they special racial characters in the plaice of this part of the Baltic? The number of vertebrae reaching its highest in the easternmost part (i.e. farthest off from the place from where the immigration must have taken place), there is any reason to believe that the high number of vertebrae is a special characteristic of the stock of plaice found in the inner Baltic; this supposition, however, is as yet based on the result of one analysis only. As to the number of rays conditions are different, because it reaches its highest in the part of the Baltic (the Arcona Basin) that is situated most closely to the doors of immigration.

If we look at Fig. 4, which presents curves showing the number of anal fin rays of the plaice, we see that these curves are varying from one water to the other. For the North Sea, the Skagerak, and the northernmost Kattegat we have a nearly ideal distribution curve with a distinct maximum about 54 and an almost uniform pitch both towards the higher and the lower values. Consequently, the curve shows that the stock of this water is of nearly unmixed descent, a typical North Sea race. In the northern Belt Sea the number of rays is somewhat lower and the curve of a less regular shape, the fall towards the low values being less steep than that towards the high ones, which shows an intermixture with plaice with a lower number of

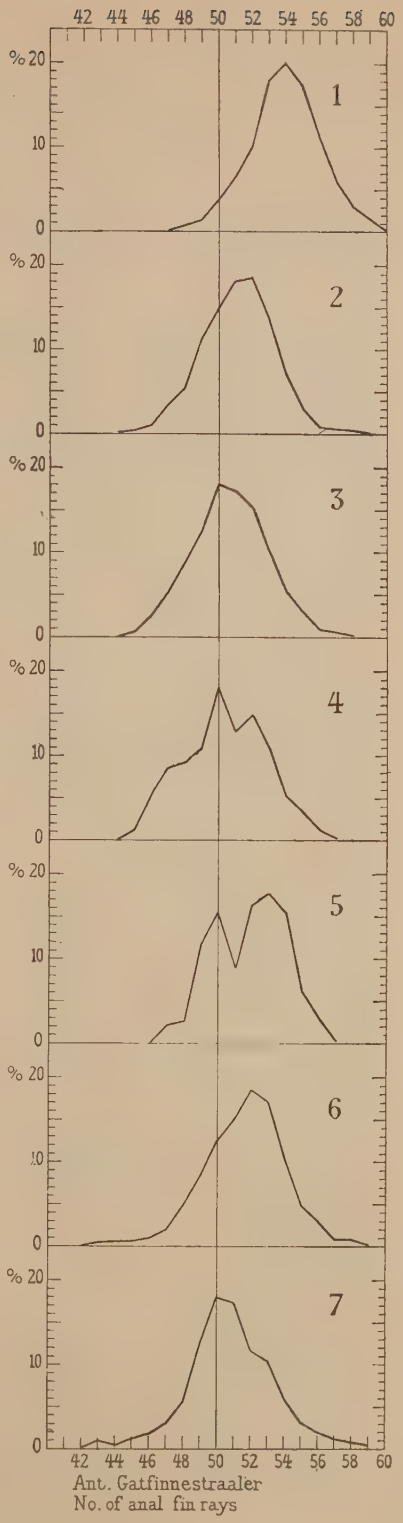

Fig. 4. Percentage frequency curves showing the number of anal fin rays of plaice from various parts of our waters: 1. North Sea, Skagerak, and Northern Kattegat, 2. Northern Belt Sea, 3. Western Baltic, 4. Waters east of Seeland, Møen, and Falster, 5. Arcona Basin, 6. Bornholm—Rügen Plateau, 7. Bornholm Deep.

rays (Baltic race). In the western Baltic the number of rays is still lower, viz. 50.65. The maximum is at 50; here we have a population consisting principally of individuals of the Baltic race. It is, however, to a certain degree intermixed with North Sea fish, for the fall of the curve towards the high values is not by far so oblique as towards the low ones. For the water east of Møen, Seeland, and Falster the curve is bimodal and rather flat; it denotes a distinctly mixed population. The Baltic race with low numbers of rays is here strongly mixed up with a race with a somewhat higher number of rays (the North Sea race). The curve from the Arcona Basin shows still more distinctly a mixed population. Here, again, there are 2 maxima, one about 50, and another about 53. The number of rays is high, 51.89, i.e. even higher than in the northern Belt Sea. The North Sea race here makes itself more distinctly felt than in the coastal waters off Møen. For the Bornholm—Rügen Plateau, again, the curve has one maximum of about 52. The plaice of the Bornholm Deep also show a curve with one maximum at 50—51. The mean number for the Bornholm—Rügen Plateau is a little lower and for the Bornholm Deep considerably lower than for the Arcona Basin. It is seen by the curves that the immigration to these two areas is at any rate of less importance than that to the Arcona Basin.

The found variation curves for the number of anal fin rays thus indicate that at any rate during later years there has been a considerable immigration of plaice (eggs, larvae, young fish) from without to the Danish coastal waters east of Seeland, Møen, and Falster as well as to the Arcona Basin, and that consequently only part of the stock which makes out the bulk of the plaice fished in these areas, has grown up in these places.

Already in 1904[1]) C. G. Joh. Petersen advanced the immigration theory; he was of opinion that the local spawning was of slight importance as compared with the immigration, that the plaice immigrated to these areas mainly as I-Group, and that they must be supposed to be derived from the nursery grounds along the German coasts of the western Baltic. This immigration theory, however, was greatly shaken when in 1906 and 1907[2]) A. C. Johansen found considerable numbers of plaice of the 0-Group at mean depths off the coasts of Falster and Møen. Further, the immigration theories were shaken by the investigations of H. Blegvad[3]) in the Baltic during 1925 when he found the 0-Group of the plaice in considerable quantities both at mean depths off Møen, Falster, and Bornholm and at the coasts of these three islands. The race analyses mentioned in the present paper seem to indicate that at any rate in certain years there is a great immigration of plaice to the Baltic from without.

In order to inquire more closely into this problem of immigration we shall

[1]) C. G. Joh. Petersen: Where, and under what Conditions, can the Eggs of Plaice be developed into Young Fish within the Skaw? — Rep. Danish Biol. Stat. XII, 1904.

[2]) A. C. Johansen: Contributions to the Biology of the Plaice with Special Regard to the Danish Plaice Fishery IV. Is the Plaice Indigenous to the True Baltic?

[3]) H. Blegvad: On the Renewal of the Stock of Plaice in the Baltic proper. — Rep. Danish Biol. Stat. XXXII, 1926.

examine the variations in the number of anal fin rays from one age-group to the other and make a comparison with similar variations in other waters (the western Baltic, the North Sea, the Skagerak).

The below tabular survey that has been worked out on the basis of material from a long series of years (1896—1931) shows the changes in the number of anal fin rays from one age-group to the other, the number of individuals being given in brackets:

Age-group	0	I	II	III	IV+
North Sea—Skagerak	54.16 (650)	54.09 (1122)	54.01 (502)	54.01 (272)	54.13 (426)
Western Baltic	49.74 (119)	..	50.00 (69)	50.80 (238)	50.77 (320)
S. of Møen—E. of Falster.....	49.62 (434)	49.52 (326)	50.80 (10)	51.00 (63)	51.46(167)[1])
Arcona Basin.....	..	..	..	52.26 (23)	51.80 (108)
Bornholm—Rügen Plateau	51.90 (130)	51.20 (275)	52.18 (287)	51.78 (167)	51.41 (76)
Bornholm Deep	50.76 (321)	..	51.71 (55)	51.19 (158)	51.31 (72)

For the North Sea-Skagerak the variations in the number of rays from one age-group to another are very small, and there is nothing to indicate a rise or a fall of the number from younger to older age-groups. In the western Baltic things are different; here the number of rays for the III- and IV+-Groups is higher than for the 0-Group by a little more than 1, viz. 50.8 for the III- and IV+-Groups and only 49.7 for the 0-Group. In the water south of Møen this rise in the number of rays from younger to older age-groups is still more pronounced. Here the 0- and I-Groups have 49.6, the II-Group has 50.8, the III-Group 51.0, and the IV+-Group 51.5 rays, i.e. a rise of 1.9 from the 0- and I-Groups to the IV+-Group. From the Arcona Basin we have no race analyses of the younger age-groups, and on the whole the material from this locality is rather sparse; the numbers of rays of the III- and IV+-Groups are rather high, viz. 52.4 and 51.8. Hence we may suppose that the material part of the individuals of these age-groups have immigrated from without. For the Bornholm—Rügen Plateau the numbers change very much and in an irregular way, in spite of the rather large number of individuals examined. The I-Group is the lowest, with 51.2, and the II-Group is the highest, with 52.18, but the 0-Group, with 51.9, is materially higher than the I-Group, and the III- and IV-Groups again are lower than the II-Group. In the Bornholm Deep the 0-Group has the lowest number of rays, viz. 50.8, whereas the II-, III-, and IV+-Groups have about 51.3 rays. The reason for the uneven distribution of the numbers of rays of plaice from the Bornholm—Rügen Plateau is possibly that from this locality we have satisfactory investigations from 1 or 2 years only. As to this area we badly want more thorough and systematic investigations.

[1]) Of those from the IV-Gr. 51.72 (51) and the V+-Group 51.32 (116).

This rise in the number of fin rays from the youngest to the older age-groups in the western and the true Baltic, especially in the water between Falster and Bornholm as compared with the uniform number of rays of the different age-groups of the North Sea-Skagerak goes to show that to the Baltic there is an immigration from without that is of importance for the preservation of the stock, and the fact that there is a rise from the 0-Group to the III-Group, but not from the III-Group to the IV+-Group seems to indicate that the immigrating plaice are principally young ones.

In order to give a more precise statement of the rise of the number of rays from one age-group to the other we shall divide the material into the different year classes and consider the number of rays within the different age-groups of the individual year classes. Even if the examined numbers of individuals of each separate age-group are often rather small, I have thought it fit for the purpose to give these numbers, as on the whole they illustrate in a uniform way the changes in the number of rays from the younger to the older age-groups within the same year class.

From the coastal waters off Seeland, Møen, and Falster we have some few analyses of the different age-groups of the same year class:

15 naut. miles S.E. by S. of Hestehoved						
13.3.1907	Year class 1906	0-Gr.	49.61	rays	(254 ind.)
S.E. of the Lightship of Møen 3.8.1907	—	—	I-Gr.	50.07	—	(41 ind.)
		Increase	+	0.46	—	
S. of Møen, June—July, 1927	Year class 1927	0-Gr.	49.23	rays	(73 ind.)
S. of Møen, September, 1928	—	—	I-Gr.	49.58	—	(53 ind.)
		Increase	+	0.35	—	
Grønsund, off Næsgaard, Aug. 1925	Year class 1925	0-Gr.	50.39	rays	(59 ind.)
S. of Møen, May 1928	—	—	III-Gr.	51.12	—	(69 ind.)
		Increase	+	0.73	—	

Thus there is within the same year class a distinct rise from the 0-Group to the I-Group and a still more pronounced rise from the 0-Group to the III-Group.

From the western Baltic we have the following observations of the number of rays in the various age-groups of the same year class:

Age-group	0	II	III	IV	V	VI
Year class 1922	49.75 (8)	..	..	51.30 (20)	50.43 (14)	50.37 (18)
— 1923	..	..	51.08 (111)	51.14 (58)	51.03 (73)	..
— 1924	50.57 (14)	49.96 (25)	51.54 (26)	51.37 (27)	..	..

Here the numbers of rays show a rise from the 0-Group to the III-Group, but not from the III-Group to the older age-groups.

From the water round Bornholm we have the following analyses of the number of rays within the different age-groups of the same year class:

In the Bornholm Deep:

Age-group	0	I	II	III	IV	V	Increase
Year class 1923	51.18(45)	..	..	..	..	51.07(26)	÷0.11
— 1924	51.38(21)	..	..	..	51.38(16)	..	0
— 1925	50.84(98)	..	..	51.36(47)	..	..	+0.52
— 1926	50.00(3)	..	..	..	51.21(14)	..	+2.21
— 1927	49.60(12)	49.75(12)	..	50.99(126)	..	..	+1.39
— 1928	50.21(95)	..	51.71(55)	..	..	..	+1.50

On the Bornholm—Rügen Plateau:

Year class 1930	51.89(113)	51.49(47)	..	..	..	..	(÷0.40)
— 1928	51.85(13)	..	52.24(263)	52.30(57)	..	..	+0.45

Thus within these areas 2 year classes show a smaller decrease in the number of rays from younger to older year classes while 5 year classes show a distinct rise.

Consequently, the race analyses of plaice from the Baltic treated above show the following characteristics as to the number of anal fin rays: 1. A bimodal percentage frequency curve with maxima at 50 and abt. 52 in the Arcona Basin and East of Møen and Falster, 2. A rise in the number of rays from younger to older age-groups, and 3. A corresponding rise from younger to older age-groups within the same year class. These characteristics can only be explained by the fact that there is a considerable immigration of plaice of the North Sea race to the said parts of the Baltic. Further, the numbers of rays show that this immigration mainly comprises only the 0-, I-, II-, and III-Groups, whereas, judging by the number of rays, the immigration of older fish is insignificant.

The immigration to the true Baltic may take place by two routes, either from the western Baltic past Gedser or direct from the Kattegat through the Sound. As mentioned C. G. Joh. Petersen (1894 and 1904) was of opinion that the young fish carried to the Baltic are derived from the German coasts of the western Baltic and thus passes by Gedser. If, however, we consider the numbers of anal fin rays of different age-groups from the western Baltic (see Table on p. 47), it will be seen that they are either as low as or lower than the corresponding numbers of rays from the true Baltic. Thus the high numbers of rays in the true Baltic are obviously not caused by an immigration of plaice from the western Baltic, but they must be supposed to be á consequence of an immigration through the Sound of plaice from the Kattegat, where the numbers of rays are rather high. Of course this does not exclude that there is also an immigration from the western Baltic past Gedser.

3. On the Relation between the Quantity of the 0-Group and the I-Group at the Coasts of the Baltic.

Also by another method than that of race analyses may an immigration of plaice of the 0-Group and the I-Group to the waters E. of Seeland, Møen, and Falster

Tabel 1. Oversigt over Antallet af Individer af samme Aargangs 0- og I

Table 1. Survey of the number of individuals of the 0- and I-Groups within the same year

Farvand *Area*	Kattegat N. f. *of* Hals						Sydlige *Southern* Kattegat S. f. *of* Hals					
Aldersgruppe *Age group*	0			I			0			I		
	Total Fangst *Total catch*	Ant. Stat. *No. of stat.s*	Ant. per ½ T. *No. per 30 min.*	Total Fangst *Total catch*	Ant. Stat. *No. of stat.s*	Ant. per ½ T. *No. per 30 min.*	Total Fangst *Total catch*	Ant. Stat. *No. of stat.s*	Ant. per ½ T. *No. per 30 min.*	Total Fangst *Total catch*	Ant. Stat. *No. of stat.s*	
Aargang 1927 *Year class*	300	24	**13**	216	17	**13**	309	15	**21**	36	25	
— 1928	405	17	**24**	1 563	16	**98**	61	25	**2.4**	161	23	
— 1929	566	16	**35**	54	16	**3**	84	23	**4**	18	21	
— 1930	259	16	**16**	477	14	**34**	210	21	**10**	264	28	
Antal Individer pr. ½ T. *No. of individuals per 30 min.*	1 530	73	**21**	2 310	63	**37**	664	84	**8**	479	97	
I-Gr. i % af 0-Gr. (samme Aargang) *I-Gr. as % of 0-Gr. (the same year class)*	**176 %**						**61 %**					

be demonstrated, viz. through an examination of the amount of 0-Group plaice in one year and of I-Group plaice in the next year caught in coastal investigations by means of Johansen's Young Fish Trawl. If no immigration takes place to a coastal area, the I-Group will be less numerous than the 0-Group of the previous year, as there will have been a decrease caused partly by death, partly by an emigration to somewhat deeper regions. But if we find no material decrease in the amount of individuals from the 0- to the I-Group, there is any reason to suppose that there has been an immigration of individuals of the 0- and I-Groups. Thus in 1927[1]) Anton Fr. Bruun pointed out that the I-Group was rather more numerous as compared with the 0-Group at the coasts of the northern Kattegat than at the coasts of the North Sea-Skagerak, and he concluded that there is an immigration of individuals of the I-Group (and probably also of older individuals of the 0-Group) from the Skagerak to the Kattegat. Further he states that such an immigration also makes itself felt in the southern Kattegat and the Belt Sea, although in a less degree. However, the material then in hand did not permit an investigation of the question whether an immigration of the same kind took place in the Baltic, too. That there are considerable immigrations of young plaice to the Kattegat was demonstrated by A. C. Johansen[2]) as early as 1910, and he wrote on the problem of extensive horizontal migrations of the plaice of our waters: "Diese Frage hat nun ihre Lösung

[1]) Anton Fr. Bruun: Quantitative Ivestigations of the 0-Group and the I-Group of the Plaice, Turbot, Brill and Sole in the Skagerak, Kattegat and Belt Sea. — Medd. f. Komm. f. Havunders. Ser. Fiskeri, Bd. VIII, 5, 1927.

[2]) A. C. Johansen: Bericht über die dänischen Untersuchungen über die Schollenfischerei und den Schollenbestand in der östlichen Nordsee, dem Skagerak und dem nördlichen Kattegat. — Medd. f. Komm. f. Havunders. Ser. Fiskeri, Bd. III, 8, 1910.

t ved Kystundersøgelser med Johansens Yngeltravl i Aarene 1927—1931.
t in the coastal investigations of the years 1927—1931 in Johansen's Young Fish Trawl.

Bælthavet *Belt Sea*					Aflandshage—Hesnæs						Skaanes Syd- og Østkyst *South and East coast of Scania*					
0		I			0			I			0			I		
Ant. Stat. *No. of stat.s*	Ant. per ½ T. *No. per 30 min.*	Total Fangt *Total catch*	Ant. Stat. *No. of stat.s*	Ant. per ½ T. *No. per 30 min.*	Total Fangst *Total catch*	Ant. Stat. *No. of stat.s*	Ant. per ½ T. *No. per 30 min.*	Total Fangst *Total catch*	Ant. Stat. *No. of stat.s*	Ant. per ½ T. *No. per 30 min.*	Total Fangst *Total catch*	Ant. Stat. *No. of stat.s*	Ant. per ½ T. *No. per 30 min.*	Total Fangst *Total catch*	Ant. Stat. *No. of stat.s*	Ant. per ½ T. *No. per 30 min.*
44	**20**	170	53	**3**	82	16	**5**	28	16	**1.8**	..	..	..	..	..	..
53	**7**	107	51	**2.1**	129	16	**8**	125	17	**8**	..	..	..	628	52	**12**
51	**1.6**	65	52	**1.3**	5	17	**0.3**	15	13	**1.2**	49	52	**0.9**	159	31	**5**
52	**5**	65	40	**1.6**	19	13	**1.5**	27	15	**1.8**	14	31	**0.5**	..	..	..
200	**8**	407	196	**2.1**	235	62	**3.9**	195	61	**3.3**	63	83	**0.8**	787	83	**9.5**
	26 %					**85 %**						**556 %**				

gefunden, was das Skagerak und Kattegat betrifft, indem durch Rassenstudien nachgewiesen ist, dass eine mächtige Einwanderung solcher jungen Fische vom Skagerak nach dem Kattegat vor sich geht." For he found that individuals of the I-Group in 1906 and 1907 had a considerably higher number of fin rays than individuals of the 0-Group in the same localities in 1905 and 1906.

Also in the coastal waters of the true Baltic off Seeland, Møen, and Falster and at the coast of Scania the I-Group is rather numerous as compared with the 0-Group as will appear from Table 1[1]). For the years 1927—1931 this Table gives the number of individuals of the same year class caught as 0-Group and as I-Group (next year). In the downmost series of figures in the Table is given the amount of the I-Group in per cent. of the 0-Group of the same year class. It will be seen that the I-Group is comparatively numerously represented in the northern Kattegat; it constitutes no less than 176 per cent. of the 0-Group. In the southern Kattegat it constitutes only 61 per cent., and in the Belt Sea only 26 per cent. But in the coastal waters of the Baltic the percentage is high again, viz. 85 per cent. at the coasts of Seeland, Møen, and Falster; and at the eastern coast of Scania no less than 556 per cent. for the one year class for which information is available both with regard to the 0- and the I-Group. These figures indicate that there is rather a considerable immigration to the coastal waters of the Baltic of older individuals of the 0-Group and of the I-Group, and thus give support to the assumption of the important immigration, which was the result of our considerations of the race analyses (see the previous chapter). In this connexion, however, we may not ignore the

[1]) The statements from the Swedish coastal area are taken from the Rapp. et Proc.-Verb. Transition Area for the years in question.

Tab. A. Antal af Hvirvler hos Rødspæ

The distribution of the variants for Vertebra

Hvirvler *Vertebrae*		Skagen *the Skaw* 28-3-1928	Nord f. Fyen *North of Funen* 29-3-1928	Vestlige Østersø *Western Baltic*			Kystvandene Ø. f. Møen og Falster *Coastal waters E. of Møen and Falster*				
				12 Sm. S.V. f. Gulstav *12 M. S.W. of Gulstav* 27-3-1928	S. for Bagenkop *S. of Bagenkop* 9-4-1928	Ialt *Total*	Ø. f. Gedser *E. of Gedser* 11-5-1928	3 Sm. S.Ø. f. Møens Fyr *3 M. S.E. of Møen L.* 8-5-1928	Ø. f. Gedser *E. of Gedser* 10-5-1928	Ø. f. Møen og Falster *E. of Møen and Falster* $^7/_5$–$^{11}/_5$-1928	Ial *Tot*
Aldersgruppe *Gr.* ..		II-VIII	II-XIV	II-XIV	III-XI		III-XII	III-VIII	III-XII	I-VI	
Vert. praec.	10	..	..	1	..	1	..	..	..	..	..
	11	2	..	5	5	10	..	..	..	1	1
	12	9	42	27	45	72	10	11	13	2	36
	13	71	143	90	127	217	34	50	71	17	172
	14	4	1	2	4	6	1	6	3	..	10
	n	86	186	125	177	306	45	67	87	20	219
	M.	12.90	12.78	12.70	12.71	12.71	12.80	12.93	12.88	12.80	12.9
	σ	0.47	0.48	0.68	0.63	0.91	0.50	0.51	0.43	0.56	0.9
	σ_m	0.05	0.05	0.06	0.05	0.05	0.08	0.06	0.05	0.13	0.0
Vert. caud.	27	..	..	1	2	3	..	..	..	..	..
	28	1	5	13	10	23	..	4	2	1	7
	29	15	39	44	65	109	16	15	32	2	65
	30	50	106	57	81	138	23	40	46	14	123
	31	20	33	9	19	28	6	8	7	3	24
	32	..	3	1	..	1	..	..	..	..	..
	n	86	186	125	177	302	45	67	87	20	219
	M.	30.04	29.95	29.50	29.59	29.57	29.78	29.78	29.67	29.95	29.7
	σ	0.68	0.75	0.98	1.00	0.98	0.71	1.06	0.74	0.69	1.0
	σ_m	0.07	0.06	0.10	0.08	0.06	0.11	0.13	0.08	0.15	0.0
Vert. Total	39	..	..	1	..	1	..	..	..	..	..
	40	1	1	5	6	11	..	..	..	..	..
	41	2	10	19	23	42	1	6	2	1	10
	42	15	54	50	71	121	20	17	40	5	82
	43	52	99	43	65	108	21	36	40	12	109
	44	16	20	7	12	19	3	7	5	2	17
	45	..	2	..	..	2	..	1	..	..	1
	n	86	186	125	177	304	45	67	87	20	219
	M.	42.93	42.71	42.20	42.31	42.26	42.58	42.71	42.55	42.75	42.6
	σ	0.75	0.84	0.98	0.95	0.83	0.88	0.89	0.85	0.76	0.9
	σ_m	0.08	0.06	0.10	0.07	0.05	0.13	0.11	0.09	0.17	0.0

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	Arkona Bassin *Arkona Basin*			Bornholm—Rygen Plateau *Bornholm—Rügen Plateau*				Bornholmsdybet *Bornholm Deep*		
17-8-1928	11 Sm. N.V.t.V. f. Rønne *11 M. N.W.b.W. of Rønne* 18-8-1928	V. f. Bornholm *W. of Bornholm* Aug. 1928	Ialt *Total*	12 Sm. S.t.Ø. f. Rønne *12 M. S.b.E. of Rønne* 20-8-1928	6 Sm. N.Ø. f. Sassnitz *6 M. N.E. of Sassnitz* 14-8-1928	Rønne Banke *Rønne Bank* Aug. 1928	Ialt *Total*	14 Sm. S. f. Nexø *14 M. S. of Nexø* 21-1-1931	4 Sm. Ø. f. Nexø *4 M. E. of Nexø* 24-8-1928	Ialt *Total*
V	III-IX	I-X		II-X	III	I-X		II-XI	III-X	
	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	1	1
	16	1	19	14	8	2	24	32	13	45
	69	2	86	35	19	14	68	154	66	220
	1	2	3	..	..	..	..	8	1	9
	86	5	108	49	27	16	92	194	81	275
.88	12.83	13.20	12.85	12.71	12.70	12.88	12.74	12.88	12.83	12.86
.35	0.45	0.87	0.45	0.54	0.55	0.37	0.51	0.46	0.47	0.46
.09	0.05	0.39	0.04	0.08	0.11	0.09	0.05	0.03	0.05	0.03
	..	..	..	..	..	..	..	..	..	..
	2	..	2	..	..	..	..	8	2	10
	22	1	28	6	7	7	20	38	22	60
	45	4	58	30	16	8	54	92	34	126
	17	..	20	12	4	1	17	50	23	73
	..	..	..	1	..	..	1	6	..	6
	86	5	108	49	27	16	92	194	81	275
71	29.90	30.80	29.89	30.16	29.89	29.62	29.99	30.04	29.96	30.02
71	0.74	1.00	0.72	0.68	0.65	0.73	0.67	0.86	0.27	0.27
17	0.08	0.45	0.07	0.10	0.13	0.18	0.07	0.06	0.05	0.05
	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..
	6	..	6	..	2	1	3	12	3	15
	22	2	35	14	9	7	30	45	26	71
	47	1	55	27	14	7	48	88	37	125
	11	2	16	8	2	1	11	45	15	60
	..	..	..	..	..	..	..	4	..	4
	86	5	108	49	27	16	92	194	81	275
76	42.73	43.00	42.71	42.88	42.59	42.50	42.73	42.92	42.79	42.88
79	0.82	1.00	0.84	0.68	0.85	0.89	1.02	0.89	0.81	0.87
19	0.09	0.45	0.08	0.10	0.16	0.23	0.11	0.06	0.09	0.05

Tabel B. Antal af Gatfinnestraaler hos Rø

The distribution of variants for anal fin rays

	Nordsøen, Skagerak og nordligste Kattegat *North Sea, Skagerak and northermost Kattegat*								Nord *North*	
	40 Sm. S.S.V. f. Graadyb *40 M. S.S.W. of Graadeep* 28-3-1922	Vigsø Bugt *Vigsø Bay* 24-9-1930	Tannis Bugt *Tannis Bay* 23-9-1930	N. f. Skagen *N. of the Skaw* 28-3-1928	Ved Skagen *Off the Skaw* 14—20-8-1927	Skagen—Sæby	Ved Skagen *Off the Skaw* 15-3, 5-4-1922	Ialt *Total*	Dalby Bugt *Dalby Bay* 29-3-1928	Kerteminde Bugt *Kerteminde Bay*
Gr.....	II-VI	0-III	I-II	II-VIII	0	0	II-VII		I-V	0-III
No.										
42.....	..	..	..	..	..	..	..	..	..	..
43.....	..	..	..	..	..	..	..	..	..	..
44.....	..	..	..	..	..	..	..	..	..	..
45.....	..	..	..	..	..	..	..	..	1	..
46.....	..	..	..	..	..	..	..	..	2	5
47.....	..	1	..	1	..	..	..	2	7	20
48.....	2	..	1	..	1	1	3	8	10	28
49.....	..	3	4	1	..	1	4	13	23	57
50.....	5	8	4	6	7	14	12	56	32	74
51.....	10	13	9	9	10	22	12	85	35	92
52.....	21	17	19	11	10	52	29	159	37	89
53.....	33	40	23	16	23	82	53	270	36	65
54.....	43	29	35	13	31	98	62	311	14	32
55.....	35	30	24	14	34	91	47	275	14	17
56.....	28	11	15	10	18	55	29	166	2	5
57.....	11	11	6	7	7	40	18	100	..	2
58.....	7	11	7	..	3	18	7	53	1	1
59.....	1	1	1	1	1	9	9	23	..	..
60.....	1	..	..	..	..	1	..	1	..	..
61.....	1	..	..	..	..	..	1	1	..	..
62.....	..	..	..	..	..	..	1	1	..	..
63.....	..	..	..	..	..	..	1	1	..	..
n	198	175	148	89	145	484	288	1 527	214	487
M.....	54.17	53.81	53.83	53.66	54.01	54.26	54.08	54.05	51.34	51.1
σ.....	2.05	2.21	2.26	2.14	1.94	2.02	2.31	2.10	2.15	2.0
σ_m	0.15	0.16	0.19	0.23	0.16	0.09	0.14	0.05	0.11	0.0

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e from different waters around Denmark.

av *lea*		Vestlige Østersø *Western Baltic*							
Northern Great Belt Jul.—Aug. 1927	Ialt *Total*	12 Sm. S.V. f. Gulstav *12 M. S.W. of Gulstav* 27-3-1928	Udf. Bagenkop *Off Bagenkop* 9-4-1928	Mellem Rødby og Femern *Between Rødby and Femern* 24-4-1922	6 Sm. S.V. f. Bagenkop *6 M. S.W. of Bagenkop* 23-3-1922	S. og V. f. Ærø *S. and W. of Ærø* Jul.—Aug. 1927	8 Sm. S.V. f. Gulstav *8 M. S.W. of Gulstav* 2-3-1927	6 Sm. V. f. Bagenkop *6 M. W. of Bagenkop* 19-2-1927	Ialt *Total*
0		II-XIV	III-XI			0	II-VIII	II-VIII	
.	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..
2	2	1	1	..	..	..	..	..	2
3	4	..	..	..	2	2	..	..	4
4	11	2	5	5	4	1	1	2	20
8	35	5	3	13	9	2	9	2	43
5	53	12	22	18	9	2	10	3	76
7	107	16	22	18	22	4	12	15	109
3	149	17	28	42	29	5	14	17	152
8	165	25	27	32	26	1	21	15	147
3	149	17	31	23	19	4	22	18	134
2	133	14	17	12	15	5	10	12	85
8	64	4	18	3	3	2	6	10	46
6	37	11	5	3	2	1	3	1	26
1	8	1	1	2	..	1	..	1	6
.	2	2	..	..	..	..	1	1	4
1	3	..	..	..	..	..	..	..	..
.	..	..	..	1	..	..	..	..	1
.	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..
1	922	127	180	172	140	30	109	97	855
0.78	51.08	50.97	50.79	50.28	50.27	50.50	50.72	51.13	50.65
2.33	2.18	2.44	2.24	2.14	2.06	2.90	2.20	2.09	2.32
0.16	0.07	0.22	0.17	0.16	0.17	0.54	0.21	0.21	0.08

Tabel B (fortsa

	Kystvandene Ø. f. Sjælland, Møen og Falster *Coastal waters E. of Sealand, Møen, and Falster*							Arkona Bassin *Arkona Basin*			
	Faxe Bugt *Faxe Bay* Aug. 1929	Ø. f. Møen og Falster *E. of Møen and Falster* Maj 1928	3 Sm. S.Ø. f. Møens Fyr *3 M. S.E. of Møen L.* 8-5-1928	Ø. f. Gedser *E. of Gedser* 10-5-1928	Hjelms Bugt *Hjelms Bay* Sept. 1928	Klintholm—Hesnæs 28-6, 21-7-1927	Ialt *Total*	12 Sm. N.V. f. Rønne *12 M. N.W. of Rønne* 17-8-1928	11 Sm. N.V.t.V. f. Rønne *11 M. N.W.b.W. of Rønne* 18-8-1928	V. f. Rønne *W. of Rønne* Aug. 1928	Ialt *Total*
Gr.....	I	III-XII	IV-VIII	III-XII	0-I	0		III-V	III-IX	I-X	
No.											
42.....	..	..	..	..	..	..	..	..	..	..	..
43.....	..	..	..	..	..	..	..	..	..	..	..
44.....	..	..	..	..	..	..	..	..	..	..	..
45.....	..	..	..	1	2	..	3	..	..	..	..
46.....	1	2	2	2	5	10	22	..	..	..	..
47.....	2	3	2	7	8	12	34	1	2	..	3
48.....	2	1	3	8	13	10	37	..	3	..	3
49.....	4	..	5	15	9	10	43	4	11	1	16
50.....	3	..	18	25	18	11	75	3	14	3	20
51.....	2	3	12	20	9	6	52	2	9	1	12
52.....	4	4	11	27	7	6	59	1	18	3	22
53.....	4	3	8	28	3	3	49	2	19	2	23
54.....	1	2	7	8	1	2	21	2	16	3	21
55.....	2	4	2	5	..	3	16	1	7	..	8
56.....	..	..	2	3	1	..	6	2	2	..	4
57.....	..	..	2	3	..	..	5	..	..	..	..
58.....	..	..	..	..	..	..	..	..	..	..	..
59.....	..	..	..	..	..	..	..	..	..	..	..
60.....	..	..	..	..	..	..	..	..	1	..	1
61.....	..	..	..	..	..	..	..	..	..	..	..
62.....	..	..	..	..	..	..	..	..	..	..	..
63.....	..	..	..	..	..	..	..	..	..	..	..
n	25	22	74	152	76	73	422	18	102	13	133
M.....	50.72	51.32	51.01	51.24	49.38	49.23	50.55	51.56	51.56	51.85	51.89
σ.....	2.63	3.12	2.34	2.33	2.19	2.32	2.60	2.67	2.06	1.94	2.42
σ_m	0.53	0.67	0.27	0.19	0.25	0.29	0.13	0.63	0.21	0.54	0.21

ble B (continued).

Bornholm—Rygen Plateau							Bornholmsdyb *Bornholm Deep*			
12 Sm. S.b.E. af Rønne *12 M. S.b.E. of Rønne* 20-8-1928	Rønne Banke *Rønne Bank* Aug.—Sept. 1931	Oder Banke *Oder Bank* Aug. 1928	6 Sm. N.Ø. f. Sassnitz *6 M. N.E. of Sassnitz* 14-8-1928	Oder Banke *Oder Bank* Sept. 1930	Oder Banke *Oder Bank* 1. Sept. 1931	*Total* Ialt	Ved Balka *At Balka* 14-8-1928	14 Sm. S. f. Nexø *14 M. S. of Nexø* 21-1-1931	4 Sm. Ø. f. Nexø *4 M. E. of Nexø* 24-8-1928	Ialt *Total*
II-IX	I-V	0-III	0-III	0-IV	I-III		0-I	II-XI	II-X	
..	..	..	..	..	..	..	..	1	..	1
..	..	..	..	..	..	..	2	1	..	3
..	..	..	1	.	..	1	1	..	..	1
..	..	1	1	..	..	2	4	1	..	5
..	..	1	1	3	..	5	6	1	..	7
1	..	..	3	10	2	16	6	4	2	12
4	2	10	3	25	2	46	11	8	3	22
3	8	9	10	42	6	78	19	19	14	52
17	11	15	12	45	12	112	11	43	18	72
7	7	21	11	78	10	134	9	35	27	71
11	21	29	12	87	14	174	13	29	9	51
11	19	14	7	96	7	154	9	26	14	49
3	20	9	6	59	4	101	6	11	7	24
2	2	6	4	29	2	45	5	6	3	14
1	3	1	2	20	..	27	..	6	2	8
..	..	1	..	5	..	6	3	2	..	5
..	..	..	2	2	..	4	2	1	..	3
..	..	..	..	3	..	3	..	..	1	1
..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
60	93	117	75	504	59	908	107	194	100	401
51.27	52.17	51.38	51.17	51.95	51.17	51.74	50.21	51.20	51.17	50.95
1.93	1.86	2.13	2.71	2.49	1.84	2.36	3.20	2.34	1.90	2.74
0.25	0.19	0.20	0.31	0.11	0.22	0.08	0.31	0.17	0.19	0.14

possibility that the I-Group being so numerous in comparison with the 0-Group at the Danish and Swedish coasts may be a consequence of an immigration of individuals of the 0- and I-Groups from somewhat deeper water. Kändler, 1931[1]) (p. 32), e.g., assumes a similar immigration of 0- and I-Group plaice from deeper water to the Oder Bank.

A closer investigation of these questions, both by a determination of the relation between the 0- and the I-Group and by race analyses of individuals of both these age-groups and through a longer series of years, too, is most desirable.

On the above pages have been treated a number of investigations from recent years (1927—31) on the stock of plaice of the Baltic. These investigations show that during this period there has presumably been a certain immigration of plaice of the North Sea race to the Baltic, more especially to the Arcona Basin with adjacent coastal areas. Hence it will be of interest to examine whether in the years in question there has been a change in the racial characters of the Baltic plaice. A. C. Johansen[2]) (1931, p. 184) writes on this problem, "The mean figure for the anal fin rays in the plaice of the Arcona Basin, the Bornholm Deep, and the Pomeranian Bay has for the year-classes 1927—30 been ca. 51.50, which is considerably above the previously observed figures." If we consider the stock of plaice as a whole in the Arcona Basin and the adjacent coastal waters where, judging from the investigations, the immigration has been most extensive, we get the following mean numbers of anal fin rays for different periods[3]):

1893—1913	50.63	(1428 individuals)
1920—1925	50.48	(260 —)
1927—1931	51.29	(1029 —)

Hence it appears that the number of anal fin rays in the years 1927—31 is higher by about 0.70 than in the previous years.

For the waters S. and E. of Bornholm were found the following numbers of anal fin rays for different periods:

1894—1895	51.16	(125 individuals)
1922—1925	50.32	(68 —)
1928—1931	51.18	(494 —)

Consequently we cannot demonstrate a rise in the number of rays for this area, nor did the race analyses suggest an immigration.

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[1]) Kändler, 1931, l. c.

[2]) Rapports et Proc. Verb. Transition Area (A. C. Johansen) Vol. LXXIV, 1931.

[3]) Partially from G. Duncker, Variation und Verwandschaft von Pleuronectes flesus und P. platessa. — Wiss. Meeresunters. N. F. I, 1895, and A. C. Johansen, 1929, l. c.

IV.

Studies on the Biology of the Oyster in the Limfjord.

IX.

On the Size of the Stock of Native Oyster.

By

R. SPÄRCK

Since 1924—25 the fishery has not worked the stock of native oyster in the Limfjord, and so it will be rather of great interest to follow the development of this stock as in the present circumstances the variations are exclusively determined by natural factors. An investigation of the stock was made already in 1927 (Spärck, Rep. Danish Biol. Stat., 1928) when it turned out that the continuous decrease of the years since 1922 had by no means come to an end with the cessation of the fishing. Since that time similar experimental dredgings have been made each year about the Fjord in order to establish the basis of an estimate of the further development of the stock. As will appear from the below results of the experimental dredgings in the summer of 1931 the stock of native oyster has by no means increased; on the contrary there has been a further decrease in the stock in spite of the fact that it has been protected through several years.

Each dredging covered an area of abt. 6000 sq.m., and both with regard to rapidity and other circumstances the dredgings were carried out in quite the same way as those of 1927 and earlier years. Although the investigation is not properly a quantitative one, the results of the successive years may no doubt be compared, and on the basis of the material we may get a fairly reliable idea of the variations of the stock.

In the Livø Broad the result was as follows in 1931:

Off Fur Hoved	0	oyster	(1927: 3 oysters)
- Vodstrup Hage	0	—	(1927: 2 oysters)
At Holmeflak	1	—	(1927: 1 oyster)
W. of Livø	0	—	(1927: 3 oysters)
Blinderøn	0	—	(1927: 1 oyster)
Langegrund	0	—	(1927: 0 oyster)
Bukser Odde	1	—	(1927: not invest.)

Thus in these 7 dredgings, covering abt. 42 000 sq.m., were taken 2 oysters in all. In 1927 13 oysters were found in fairly the same area. As appeared from the measures of the oysters taken in 1927 they were all of them big and old individuals of 9 to 12 cm., so that, on the whole, we are not surprised by the fact that this stock

turns out to have decreased further after 4 years. At present the stock of native oyster of the Livø Broad must be considered nearly extinct.

In close accord with the results of previous years conditions in the Risgaards Broad in 1931 proved to be rather different from those of the Livø Broad.

Off Eskjær	4	oysters
- Grettrup	7	—
- Stistrup	2	—
Rindgrund	1	—
Off Illeris	6	—

Here, then, 20 living oysters were found within 30 000 sq.m. In 1927 when dredgings were made in 6 localities, i. e. abt. 35 000 sq.m., 30 oysters were found. Hence, the decrease of the stock in this part of the Limfjord is much smaller than in the Livø Broad. According to the investigations of 1924 and 1927 this was to be expected, some younger individuals being found in this part of the Fjord in the said years. This also turned out to be the case in 1931 when 3 out of the 20 oyster were younger individuals of abt. 7 cm. Thus for the Risgaards Broad and Hvalpsund we may state a certain decrease, but still some young oysters will grow up, so that for this part of the Fjord we need not fear any utter extinction of the stock.

Conditions in the Thisted Broad are exactly the same as in the Risgaards Broad.

Feggesund	5	oysters
Skærbæk Sten	0	—
Midst of the Broad	3	—
Off Faartoft	3	—
- Silstrup	3	—

In these 5 localities, representing abt. 30 000 sq. m., were taken 16 oysters in all as against 17 in exactly the same localities in 1927, the decrease thus being negligible. In 1927 there were a few younger oysters, and among the 16 oysters of 1931, too, one or two individuals were 5 years old at the highest. Thus there is apparently a certain renewal of the stock in this place.

In the Venø Bay dredgings were made in the following localities:

Off Hanbjerg	0	oyster
Nygaards Hage	0	—
Kaas Krog	3	—

Within these 18 000 sq.m. 10 oysters were taken in 1927 as against 3 in 1931. Here, then, a considerable decrease could be stated, too. As late as 1924 there were some young oysters in the Venø Bay, but neither in 1927 nor in 1931 were any young oysters to be found.

Also in the Nissum Broad the population of 1931 has decreased somewhat as compared with that of 1927. The following localities were worked:

Off Mullerne	2	oysters
Røjensø Hage	8	—
Nr. Nissum	1	—
Off Flovlev	2	—
Toftum	5	—
St. Knæ	6	—

This is a total of 24 oysters from an area corresponding to one which yielded 54 oysters in 1927. However, some few of them, 4 in all, are young, one of them being only one year old. Thus, in spite of the fact that the stock is also decreasing here, the native stock is constantly renewed, and there is consequently no liability of a complete extinction of the native population of the Nissum Broad.

Judging by the above facts there can hardly be any doubt that the native stock of oyster in the Limfjord is still decreasing in spite of the fact that it has not been worked during these 6 or 7 years. This is no doubt due to the natural conditions being infavourable to the propagation of the oyster in the Limfjord as has formerly been demonstrated. This would seem to confirm the hypothesis that the fluctuations of the stock of oyster in the Limfjord mainly depend on the natural conditions, more especially because the fluctuations within the various parts of the Limfjord are not uniform. The decrease in the Thisted Broad and the Risgaards Broad, e. g., is negligible; it is somewhat greater in the Venø Bay and the Nissum Broad and really enormous in the Livø Broad. That the decrease is specially slight in the two former broads corresponds very well with our knowledge of the biology of the oyster, for here we have the highest summer temperatures. The very high decrease in the native stock of the Livø Broad is no doubt due to the high mortality during the winter in this very place.

The continued investigation of the native stock of oyster in the Limfjord has only served to confirm the supposition that natural conditions are her so unfavourable to the propagation of the oyster, that only during certain rather brief periods (as in the years 1868—1880 and 1912—1922) a profitable fishing on a larger scale may be based on the native stock exclusively. In most years the conditions of propagation of the oyster will be so bad, that the stock may barely be preserved, and in great parts of the Fjord it will even decrease. In these normal but unfavourable years especially the warmer inner broads will show some degree of renewal of the stock. And it seems that both here and in the Nissum Broad and the Venø Bay the spat-fall is in most years confined to some few localities with specially favourable conditions of current. What happens in "good oyster years" is an enlarging of the stock over the Fjord. During these years in which there is both a great production of pelagic fry and a considerable increase in the percentage of surviving fry, the spat-fall is

not confined to comparatively few localities. A series of such good years succeeding each other fairly rapidly, as in the case of the years 1910—14, will result in a population dispersed all over the western part of the Fjord, and in the unfavourable years this population will "retire" to the few specially favourable regions. Thus the natural conditions are no doubt the main factor determining the fluctuations in the size of the population. The native stock of oyster is hardly liable to die out completely. There will always be some oysters left in certain localities. If part of the rational fishery based on the relaying of spat were transferred to the inner broads, there is a possibility that by this means we might improve the conditions for the increase of the native stock in case a period with climatic conditions favourable to the propagation of the oyster should come about. But beyond this it is hardly possible to influence the fluctuations of the native stock in an artificial way. Now and in future the main stress must be undoubtedly be laid on a fishery based on relaying of purchased spat.

V.

On the Capability of Migration of Adult Individuals of *Asterias rubens.*

By

R. SPÄRCK

Through marking experiments we have learned a good deal about the migrations of our common food fish, but we know very little about the capability of migration of marine invertebrates. Is e. g. an adult star-fish, *Asterias rubens*, able to cover any considerable distance? If for some reason the stock of *Asterias rubens* is exterminated or disappears from a certain locality, will then within a short time the stock of the surrounding regions migrate into this area?

During my investigations of the biology of the oyster in the Limfjord I have had an opportunity of making some observations as to this subject. Our knowledge of the migrations of such animals being so very small, even these casual observations may be of some interest.

Since 1925 the dredgings for oyster in the Limfjord have been concentrated within quite a small area of some few hectares in the Nissum Broad. This area is worked almost continuously from September to May every year. One of the consequences of this intense dredging is that rather a great part of the rich natural fauna of this area has been exterminated as appears clearly from the following dredging results within and outside the said area.

On oyster-bed, depth 6 m., dredging for 10 minutes with 7 dredges:

4 *Asterias rubens*, 4 *Buccinum undatum*, 2 *Eupagurus*, 0 *Mytilus edulis*, 0 *Hyas*, 0 *Carcinus mænas*.

Outside oyster-bed, abt. 100 m. from the said locality, depth and condition of bottom the same, dredging for 10 minutes with 7 dredges:

Abt. 1000 *Asterias rubens*, 17 *Buccinum undatum*, 11 *Eupagurus*, abt. 100 *Mytilus edulis*, 26 *Hyas*, 7 *Carcinus mænas*.

These two dredgings were carried out on April, 25th, 1928, at the close of the oyster season during which the former localities had been worked continuously for 8 months, whereas no dredgings had been made within the latter area. So one would expect a great part of the bottom fauna to have disappeared from the oyster-bed. A long series of other dredgings within and outside the oyster grounds of the Nissum Broad have given the very same result, viz. a huge population of *Asterias rubens* outside and nearly none inside the areas.

As mentioned no dredgings are made during the 4 summer months, May—August, and so it was to be expected that the rich fauna of *Asterias*, *Buccinum*, *Hyas*, etc. during these 4 months would invade the oyster-beds. However, a series of dredgings in late summer has proved that this takes place to a very small extent only.

A 10 minutes' dredging with 7 dredges on June, 13th, and July, 11th, 1928 in the same locality as above gave the following results within the oyster-bed: 35 *Asterias rubens*, 14 *Buccinum*, and 11 *Eupagurus* on June, 13th; but only 30 *Asterias*, 3 *Carcinus*, and 10 *Buccinum* on July, 11th. A third dredging in late August gave practically the same result: 40 *Asterias*. But throughout the summer a similar dredging would give 800—1000 *Asterias rubens* abt. 100 m. outside the oyster-bed.

This proves that during the 4 summer months only very few *Asterias rubens* cover the distance of a few hundred metres into the oyster-ground in spite of the fact that it is surrounded on all sides by hundreds of thousands of star-fish and in spite of the occurrence of several millions of small oyster on the oyster-bed. The other larger bottom invertebrates, however, e. g. *Hyas*, *Carcinus*, *Eupagurus*, and *Buccinum* seem to a somewhat higher degree to invade the oyster-bed in the course of a short time.

Thus it seems that the stock of *Asterias rubens* is locally confined and that the migrations of the adult individuals are inconsiderable. At any rate the occurrence of a dense population of oyster does not seem to attract the *Asterias*. A practical fishery-biological consequence of this must be the possibility of exterminating the *Asterias rubens* within limited areas.

VI.

Preliminary Investigation of the Content of Bacteria in the Limfjord Oyster.

By

R. SPÄRCK & E. LANGE

While we have a considerable number of investigations on the content of bacteria in the oyster, made in Holland, England, France, and other countries, such investigations have so far been lacking as far as the Danish oyster is concerned. No doubt this is principally due to the fact that such investigations have been considered perfectly superfluous from a hygienic point of view. The Limfjord oyster occurs in localities situated several kilometres from inhabited places. In the western Limfjord there are no larger towns at all, so that the possible pollution on the beds must be quite insignificant. Further, habitations are too scatteringly placed over the country round the Limfjord, especially in consideration of the great distances to the oyster-beds, the huge bodies of water, and the rather considerable movements of the water. As will appear from the following the possibility that the Limfjords oyster in the very places of occurrence might be infected by Coli bacteria and other hygienically undesirable organisms has been neglected, and no doubt rightly. After the dredging the oysters are taken to the large basins of the Limfjordsøsterskompagni on the Ørodde at Nykøbing Mors, where they are generally kept for some weeks before they are sent off to the consumers. These basins are fed with running salt water which is pumped in from the Limfjord near the point of the Ørodde. Now there is still a possibility of infection left, viz. that the water which is pumped into the basins might contain Coli bacteria, etc. as there is only a distance of 1 km. from the point of the Ørodde to the harbour of Nykøbing where at times the water is liable to be polluted by the ships.

In order to find out the content of bacteria of the Limfjord oyster we have made the following preliminary and orientating investigation. The investigation was made during the months of October, 1931—March, 1932, by making a total of 12 samples of oyster the object of a bacteriological investigation. Each sample included 4 categories of Limfjord oysters, viz. oysters taken direct from the beds (A), oysters which had been kept for a few days in the basins on the Ørodde (B), oysters which had been kept in the basins for a fortnight (C), and finally oysters which had been kept for about 4 weeks (D).

In the investigation the following method was applied. The first samples examined were only treated in this way: the outside of the oyster shells was sterilized, and then the shells were opened with a sterile knife after which part of the gills and

the fluid between the shells was grafted on a lactose-agar plate which had been coloured with bromine-thymol-blue. In cases when growth of acidifying colonies appeared on the plate they were made the object of a closer microscopic scrutiny. If in this investigation Gram-negative bacilli appeared, the colony was examined in detail at Statens Seruminstitut as regards the fermentative power against all kinds of saccharine. We beg to thank Kai Jensen, Branch Director, M. D. and V. Lester, M. D. for their kind assistance in this investigation. Further we offer our thanks to Prof. Aug. Krogh, Ph. D., Director of the Zoo-physiological Laboratory, for his kindly permitting us to use his laboratory for the investigation. Soon, however, we abandoned the above mentioned preliminary method, and instead of using a grafting needle we proceeded to apply the method of rubbing a piece of gill cut off with a sterile knife, on the agar plate. Later on, instead of the lactose-agar plate we used lactose bouillon thus getting an opportunity of watching both changes in colour and evolution of carbonic acid. Finally, instead of grafting with needle or using pieces of the oyster cut off with a sterile knife, we pounded the whole oyster in a sterilized mortar, and of the emulsion formed in this way 0.5 c. c. was inserted into the lactose bouillon or mounted on lactose-agar plates. Otherwise we proceeded in quite the same way as mentioned above; if acidifying colonies appeared in the tubes they were made the object of a closer microscopic scrutiny, and if Gram-negative bacilli were found a detailed investigation was made at the Seruminstitut.

What mainly interests is the question whether there may be said to be a pollution of any importance, and so we have principally endeavoured to ascertain the possible occurrence of Coli bacteria. As will appear from the below table practically no Coli bacteria are found among the Limfjord oysters in the said period, as we

	A				B				C				D			
	— Growth	slight Growth +	ample Growth +	+ Coli	— Growth	slight Growth +	ample Growth +	+ Coli	— Growth	slight Growth +	ample Growth +	+ Coli	— Growth	slight Growth +	ample Growth +	+ Coli
$^{21}/_{10}$	1	1	..	..	1	1	..	..	..	2	..	..	2	..	..	..
$^{29}/_{10}$	1	..	1	..	..	..	2	..	2	..	..	..	2	..	..	..
$^{8}/_{11}$	..	1	1	..	..	..	2	..	1	1	..	..	1	1	..	..
$^{13}/_{11}$	..	2	..	..	..	..	2	..	..	8	..	..	3	5	..	..
$^{21}/_{11}$	2	..	..	..	2	..	..	..	3	5	..	..	4	4	..	..
$^{28}/_{11}$	1	..	..	..	..	1	..	..	6	2	..	..	1	5	2	..
$^{18}/_{12}$	..	4	..	..	..	1	..	..	2	1	1	..	2	1	1	..
$^{19}/_{12}$	..	1	..	..	..	..	..	..	..	..	1	..	..	..	1	..
$^{25}/_{1}$	..	1	1	..	1	..	1	..	..	1	..	1	..	1	1	..
$^{26}/_{2}$	..	1	..	..	1	..	..	..	4	9	7	..	1	..	..	..
	5	11	3	..	5	3	7	..	18	29	9	1	16	17	5	..
	26 %	58 %	15 %		33 %	20 %	47 %		32 %	50 %	16 %	1,7 %	42 %	45 %	13 %	

have only in one case found a very small amount of Coli bacteria among the oysters which were made the object of a closer examination. So we may be justified in assuming that this infection is due to a mere accident and that in general we may consider the Limfjords oyster so slightly polluted that no Coli bacteria occur.

The table also shows that in rather a high percentage of Limfjords oysters there is so small an amount of bacteria, that there is no growth even after the application of the thorough method of mounting 0.5 c. c. of pounded oyster on the plate. These individuals free from bacteria are distributed among the 4 categories of examined oysters in such a way, that most of them are found among the oysters that have been kept in basin for 4 weeks, while the smallest amount is found among the oysters which are taken direct from the Fjord. This again means that the total content of bacteria in the oyster decreases during the stay in the basins, the stay thus, as was to be expected, having a sterilizing effect on the oyster.

In the table we have further made a distinction between slowly growing colonies which are supposed to consist mainly of marine bacteria, and rapidly growing colonies which, however, are free from Coli bacteria. The former are specially numerous in oysters which are taken direct from the Fjord and have not been kept in the basins. It must be supposed that here we have to do with bacteria that occur normally in the water of the Fjord and therefore decrease rapidly in quantity when the oyster is removed to the basins where conditions are different. Rapidly growing colonies free from Coli bacteria generally occur only in abt. 15 per cent. of the oyster. Only among the oysters which have just been transferred to the basins there seems to be an increase in the growth of these bacteria which afterwards, like the rest of the bacterium flora, decrease in number during the stay of the oyster in the basin.

The results of this preliminary investigation may be summed up as follows. A pollution of the Limfjords oyster of any importance whatever is out of the question. Coli bacteria are so sparse, that their occurrence must be characterized as a mere accident, and on the whole the content of bacteria is insignificant. In the main we have to do with slowly growing forms. The oysters which have been kept for the longest time in the basins on the Ørodde show the highest number of individuals free from bacteria, which may only be interpreted to the effect that the stay in the basins furthers the sterility. We shall hope to be able to make more thorough investigations in this field.

VII.

On Aerial Spotting of Fish Shoals. II. Danish Experiments in 1931.

By

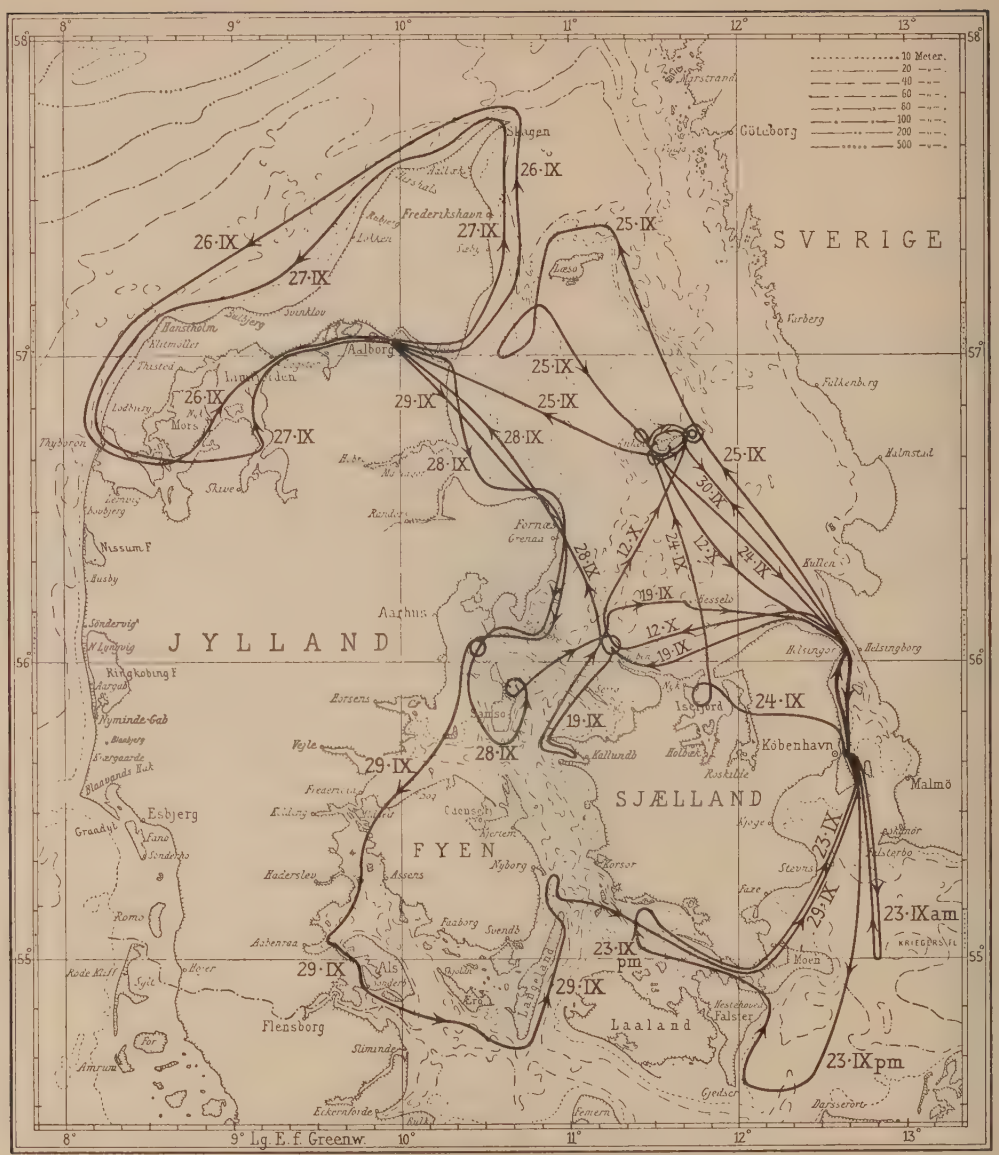
H. BLEGVAD

On the basis of the Danish experiments made in 1930 with the purpose of locating fish shoals from aeroplane (see H. Blegvad: Aerial Spotting of Fish Shoals. Danish Experiments in 1930. Rep. Danish Biol. Stat. XXXVI, 1930) I proposed in the said paper a continuation and an extension of the experiments in the following year. As, moreover, reports from Iceland (see, e.g. A. Johannesson in Ny Svensk Fiskeritidsskrift Nr. 4, 15 Febr. 1931) and from Norway (according to kind information given to me by Asserson, Director of Fisheries, Bergen) showed encouraging results of the aerial spottings of herring in the countries in question, the Danish Biological Station in 1931 again applied to the Ministry for Naval Affairs that one of its seaplanes might be put at the disposal of the Station for a brief period in September, 1931. The Ministry for Naval Affairs and the Naval Air-Service most kindly complied with the request, and the flyings were started on Sept., 19th, 1931.

As the experiences of the Icelandic investigators seemed to indicate that especially the early hours of the morning and, sometimes the afternoon hours as well were best suited for the observation of herring shoals, we determined as far as possible to make the observations at these hours. Further the former observation area, viz. the Kattegat and the Belt Sea, was extended to comprise the Skagerak and the western part of the Baltic as well. The seaplane used, H.M. II. Nr. 97, was a 3-seated Heinkel Seaplane with a Jaguar motor of 440 h.p. The first flying, on Sept., 19th, was made by Th. Petersen, Assistant Gunner, the others by I. J. Münter, Naval Lieutenant, with V. E. Kramme, Air Mechanic, as wireless operator. The author himself was leader and observer except at the flying on Oct., 12th, when Dr. E. M. Poulsen took my seat. Further, at the flyings from Sept., 23rd p.m. to Sept., 29th incl., we were for safety's sake accompanied by the seaplane H.M. II. Nr. 88 with Th. Petersen, Chief Gunner, as pilot and Fr. Hansen, Air Mechanic, as wireless operator.

Before the beginning of the flyings an arrangement was made with the Danish Broadcasting Corporation to the effect that the information which might be submitted to it from the aircraft via the wireless of the Naval Air-Service as to the results of the observations, should at once be broadcast.

The routes traversed are marked down on the chart on p. 78.



Flying Routes during the Searches for Fish Shoals in September and October, 1931.

On Sept., 19th, we started from Copenhagen at 7.45 a.m. Route: Helsingør—Gilleleje Flak—Sjællands Odde—Refsnæs—Kallundborg Fjord—Sjællands Rev—Schultz Grund—Hesselø—Gilleleje—Copenhagen. Landing at 10.40 a.m.

Flying time: 2 hours 55 min.
Weather: Overcast.
Wind and Sea: W.—N.W., 3 Beaufort.
Conditions of observation: Fairly good.
No fish shoals observed.

On Sept., 20th—22nd, we did not start on account of rough weather.

On Sept., 23rd, we started from Copenhagen at 5.45 a.m. and flew to a point 8 naut. miles E. of Møen, from where we returned to Copenhagen on account of falling oil pressure.

Flying time: 1 hour.
Weather: Bright.
Wind and sea: N.W., 2 Beaufort.
Conditions of observation: Good.
No fish shoals observed.

Fresh start at 4.05 p.m. from Copenhagen. Route: Møens Klint—Gedser—Grønsund—Smaalandsfarvandet—Bøgestrømmen—Stevns—Copenhagen. Landing at 6.25 p.m.

Flying time: 2 hours 20 min.
Weather: Cloudy.
Wind and Sea: N.—N.E., 3 Beaufort.
Conditions of observation: Fairly good.
In Grønsund we passed about 20 herring-boats outward bound. At Jungshoved in Bøgestrømmen we saw a few seals; no fish were observed.

On Sept., 24th, we started at 5.55 a.m. from Copenhagen. Route: Isefjord—Hesselø—round Anholt—Helsingør—Copenhagen. Landing at 8.25 a.m.

Flying time: 2 hours 30 min.
Weather: Cloudy.
Wind and sea: N.N.W.—N.N.E., 1—2 Beaufort.
Conditions of observation: Good.
2 naut. miles S.S.W. of Anholt a shoal of herring of abt. 1000—2000 was observed at 6.55 a.m.; near it were seen a few seals. At the Eastern Reef of Anholt about 50 seals were observed.

On Sept., 25th, we started from Copenhagen at 6.00 a.m. Route: Helsingør—round Anholt—Læsø Trindel—Østre Flak—Anholt. Landed here because of fog at 8.30 a.m. Fresh start from Anholt at 11.30 a.m; at Aalborg at 12.30 a.m.

Flying time: 3 hours 30 min.
Weather: Slightly cloudy. Fog in the northern part of the Sound and in the northern and western part of the Kattegat.
Wind and sea: W.—N.N.W., 1—2 Beaufort.

Conditions of observation: Apart from the fog, good.

At 6.30 a.m. was observed a shoal of herring of about 5000 individuals 15 naut. miles N. of Nakkehoved. At the Anholt Eastern Reef about 30 seals were seen.

On Sept., 26th, we started from Aalborg at 6.10 a.m. Route: Hals—Læsø Rende—the Lightship of the Skaw—Hirshals—Hanstholm—Thyborøn—Aalborg (in the Kattegat and the Skagerak we mainly followed the 40 m. depth curve). Landing at 9.15 a.m.

Flying time: 3 hours 5 min.

Weather: Slightly cloudy.

Wind and sea: N.E.—N.N.E., 3—4 Beaufort.

Conditions of observation: Fairly good in the Kattegat and the southern Skagerak. In the northern Skagerak less good.

About 2 naut. miles from the coast, between Sæby and Frederikshavn a shoal of mackerel of about 50 000 was observed. The shoal apparently moved in a southward direction.

About 4 naut. miles to the N.W. of Thyborøn several groups of dolphin (*Delphinus delphis*) were seen.

On Sept., 27th, we started from Aalborg at 6.10 a.m. Route: The same as the day before, although nearer to the coast, mainly along the 20 m. depth curve.

Flying time: 3 hours 5 min.

Weather: Overcast. Showers at Hanstholm.

Wind and sea: N.W., 3—5 Beaufort.

Conditions of observation: Not good because of the ripply sea.

No fish shoals observed.

On Sept., 28th, we started from Aalborg at 6.10 a.m. Route: Hals—Fornæs—Sletterhage—Vestborg—Lyshage—Stavns Fjord—Sjællands Rev—Schultz Grund—Fornæs—Aalborg. Landing at 9.00 a.m.

Flying time: 2 hours 50 min.

Weather: Cloudy.

Wind and sea: N.—N.N.E., 3 Beaufort.

Conditions of observation: In most places bad, because of ripply sea.

No fish shoals observed.

On Sept., 29th, we started from Aalborg at 8.15 a.m. Route: Fornæs—Hjelm—Sletterhage—Mejlflak—Endelave—Baaringvig—Gamborg Fjord—Aarø—Aabenraa Fjord—Alssund—Kjels Nor—Vresen—Smaalandsfarvandet—Bøgestrømmen—Stevns—Copenhagen. Landing at 12.25 p.m.

Flying time: 4 hours 10 min.

Weather: Cloudy.

Wind and sea: W.—N.W., 1 Beaufort.

Conditions of observation: Very good.

At Hjelm, Als, Langeland, in the Great Belt and in the Smaalandsfarvandet large flocks of eider ducks and black divers were seen. At Mejlgrund a few seals were observed, and in Køge Bugt some porpoise.

No fish shoals observed.

On Sept., 30th, we started from Copenhagen at 9.10 a.m. Route: Helsingør—round Anholt—Helsingør—Copenhagen. Landing at 11.30 a.m.

Flying time: 2 hours.

Weather: Overcast.

Wind and sea: S.W.—W.S.W., 1—2 Beaufort.

Conditions of observation: Very good.

At the Anholt Eastern Reef about 100 seals were seen. No fish shoals observed.

On Oct., 12th, we started from Copenhagen at 2.15 p.m. Route: Helsingør—Sjællands Rev—Schultz Grund—round Anholt—Helsingør—Copenhagen. Landing at 4.50 p.m.

Flying time: 2 hours 34 min.

Weather: Hazy.

Wind and sea: S.W.—S.S.E., 1—2 Beaufort.

Conditions of observation: Good.

At the Anholt Eastern Reef about 50 seals were seen. No fish shoals observed.

The total flying time was 30 hours (besides, the accompanying seaplane flew 21 hours 30 minutes in all), which is considerably longer than in 1931. As in the previous year the flyings were generally made at a height of 200—400 m., rarely up to 600 m. above sea level. The experiences showed that conditions of observation of fish shoals were best in cases of cloudy weather and calm wind and sea (force of wind 2 Beaufort at the highest). By bright weather we were highly disturbed by the reflections of the sun from the surface of the sea, even by calm weather. Also rough sea with breaking waves made the observation difficult, although not impossible.

In no case fish shoals were seen playing in the very surface of the water, as is often reported to be the case in other countries. The shoals observed went a little, presumeably 1—3 m. below the surface. The distance between the individual fishes of the shoal was very small; it was estimated at less than $^1/_2$ m.

As in 1930 we found at all flyings over the Anholt Eastern Reef a large stock of seals which obviously have a place of resort here. At other places, too, e.g. at Bøgestrømmen and in the Samsø Belt seals were observed, although never in large numbers. All of them were spotted seals (*Phoca vitulina* L.). An attempt at taking moving pictures of the swimming movements was unsuccessful because of the vibrations of the aircraft.

During the flying on Sept., 29th, 1931, under ideal conditions of observation enormous flocks of birds were observed in the Belt Sea. The bulk of them consisted of black divers (*Oedemia nigra* L.), brown divers (*Oedemia fusca* L.), and eider ducks

(*Somateria mollissima* L.). When such a flock of birds rose on the wing, it looked from a distance as if a large shoal of fish stirred up the surface of the water.

In this connexion it should be mentioned that according to the results of the present investigations an aircraft will no doubt be very useful in special investigations as to amount and occurrence of such animals as seals and sea-birds. Our waters are of so small an extension that a few days' flying will suffice for giving a notion of numbers and distribution of the various species occurring in this country; by some training one will easily be able to distinguish the species from a height of about 200 m. above sea level.

As mentioned above observations of fish shoals were at once communicated to the Danish Broadcasting Corporation for transmission through the Broadcasting News, but we have received no information whether the communications were of any use to the fishermen. The herring shoals were rather small, and the large mackerel shoal, which was observed on Sept., 26th, went so close to the shore that it has no doubt especially been caught in the pound nets along the shore.

On the basis of the experiments made in 1930 and, especially, in 1931, in which year the flyings were made on rather a large scale and under favourable conditions at the most, it may now be considered a fact that also in our waters fish shoals may be spotted from the air. But considering the heavy costs of the flyings (the Air-Service reckons abt. 300 Kr. per flying hour), it is also rather obvious that the fish shoals which might probably be observed from a seaplane in our waters, will be too few and too small to pay the organisation of a rational aerial spotting of such shoals. Obviously the shoals in our waters generally go at a greater depth than is the case e.g. at Iceland, and occurrence in large numbers of birds or whales which at Norway is very often used by the pilots as an indication of the occurrence of herring is not of any great importance as guidance in the Danish waters. So the experiments of the Danish Biological Station must now be considered finished. —

It is my pleasing duty to express my thanks to both the Ministry for Naval Affairs and to the Naval Air-Service for the assistance given. Especially I beg to draw the attention to the untiring ardour and the most valuable help to carry out the experiment given by the Chief of the Naval Air-Service, A. E. V. Grandjean, Commander-in-Chief, and by the Chief of the Naval Aviation Base, P. Scheibel, Commander R. N. Further I give my best thanks to the pilots and mechanics mentioned above, who all in an excellent way did their part of the work.

VIII.

Preliminary Report on the Danish Experimental Transplantations of Plaice From the North Sea to the Belt Sea During the Years 1928—31.

By

H. BLEGVAD

Both Danes and Germans have formerly carried out experiments of transplantation of young plaice from the North Sea to the Belt Sea[1]). In the experiments the fish were marked, and in all cases it turned out that the plaice were growing well, but only a very small part of the marked fish were re-captured. Thus, after the transplantation experiments of 1922 only from about 2 to about 15 per cent. of the transplanted and marked plaice were re-captured, whereas a total of about 50—70 per cent. was re-captured in all the marking experiments of local Belt Sea plaice. The low percentage of re-capture of the transplanted North Sea plaice must be ascribed to a high mortality among the fish, but the cause of this high mortality cannot be definitely stated.

The extensive transplantations of plaice in the Limfjord carried on through the instigation of Dr. C. G. Joh. Petersen during a longer series of years are wellknown. The plaice are transplanted from the Nissum Broad, where there is an "over-population" of plaice and small quantities of food to the inner broads of the Limfjord at Thisted, Løgstør, and Skive, where plaice are few and food is abundant. Every year since 1908, with the exception of one of the years of the war, between 1 and 2 millions of young plaice have been transplanted to the inner broads of the Limfjord. The Danish Government grants an annual amount of 20 000 Kr. to these transplantations.

The intense fishing of recent years has reduced the population of plaice in the Belt Sea perceptibly. The Limfjord fishermen gradually came to consider the transplantations in the Fjord an effective and necessary part of the endeavours of the Government to further the commercial fishery, and so the question arose: would it not be expedient to transplant plaice to the Belt Sea in a similar way? The above mentioned low percentage of re-capture in the Belt Sea of transplanted plaice might be due to a wrong treatment in the transport of the fish, and this might then be corrected on the basis of the experiences gained through the transplantations in the Limfjord.

In October, 1926, Dr. A. C. Johansen proposed to make a preliminary experiment in order to examine the adaptability of the North Sea race to the low

[1]) The Belt Sea is here taken in its widest sense, comprising the entrances from the Kattegat to the Baltic, viz. the Sound, the Samsø Belt, the Great Belt, the Lesser Belt, and the western part of the Baltic.

salinities of our inner waters. A small quantity of living plaice caught in the Nissum Broad were put into fish-ponds in 6 different harbours, viz. Thyborøn, Hals, Grenaa Koldby Kaas, Bagnkop, and Karrebæksminde, abt. 200 plaice being put into each fish-pond. The chairman of the local association of fishermen inspected the plaice every day; after 14 days the experiment was concluded, and it turned out that only a low percentage (5—15) of the plaice had died, even in the harbour of Karrebæksminde, where the salinity ranges between 5.5 and 13 pro mille, while in the Nissum Broad it is 28—30 pro mille.

On the favourable results of this experiment was organised the first great experimental transplantation of plaice to the Belt Sea in April, 1928.

A total of 1 430 000 plaice were transplanted to the southwestern Kattegat, the Isefjord, and the Belt Sea. Abt. 300 000 of them had been caught in the Horns Reef Area, the rest at Thyborøn, especially in the Nissum Broad in the Limfjord. The fish originating from the Horns Reef Area were carried in lorries by land from Esbjerg to Fredericia, and were considerably larger than those originating from the Limfjord and Thyborøn. The average weight of the Esbjerg fish was 2.3 kg. per score, while that of the Limfjord fish was only 1.05 kg. per score. The costs of the transplantation of the plaice amounted to a little more than 3 Øre a piece.

The proceeding of transplantation was as follows. The fish from the Limfjord and Thyborøn were caught in Danish seine from small boats, from where they were transferred to well boats that would carry from abt. 2 500 to abt. 3 500 kg. These well boats took the fish to the places of liberation, where they were received by the inspection vessels "Falken" and "Havørnen", the staff of which inspected both the condition and the quantity of the fish. Apparently a very low percentage of the fish had suffered in the transport and only a very small number had died. — The fish originating from the North Sea, which were carried by land, were put into fish-ponds off Fredericia Harbour, where they were kept for 5 days, before well boats carried them to the places of transplantation; when liberated these plaice seemed to be just as vigorous as the fish that were carried with well boats direct from the place of capture to the place of liberation.

3.000 of the transplanted fish were marked and put out in 30 different localities; further were marked 430 "local" plaice, i.e. plaice caught in the Belt Sea. At the end of December, 1928, 13 per cent. of the transplanted, but 41 per cent. of the "local" fish had been re-captured. On December, 31st, 1928, these figures had risen to 18 and 60 per cent., respectively.

This comparatively small figure for the re-capture of transplanted fish seemed to indicate that the plaice had still in many cases suffered from the transport. So it was decided that the boats which transported the fish should carry comparatively smaller cargoes. But as mentioned experience had shown that the fish originating from Esbjerg thrived as well as those caught at Thyborøn and at the Nissum Broad, and the transport being in the former case far shorter, it was decided to take all the fish for the transplantation of the next year from the Horns Reef Area.

During the experiments of 1928 it had turned out that part of the fish originating from Esbjerg still had remains of shells in their intestines when they arrived at Fredericia, so that during the packing and the transport by land the shell fragments might damage the intestines of the plaice. Therefore an arrangement was made that the fish should be kept in fish-ponds for two days at Esbjerg before they were carried by land to Fredericia, while the time of keeping at Fredericia was reduced from 5 to 3 days.

From April, 17th, to May, 7th, 1929, about 1 047 000 plaice with a weight of about 107 000 kg. were transplanted from the Horns Reef Area to the Belt Sea

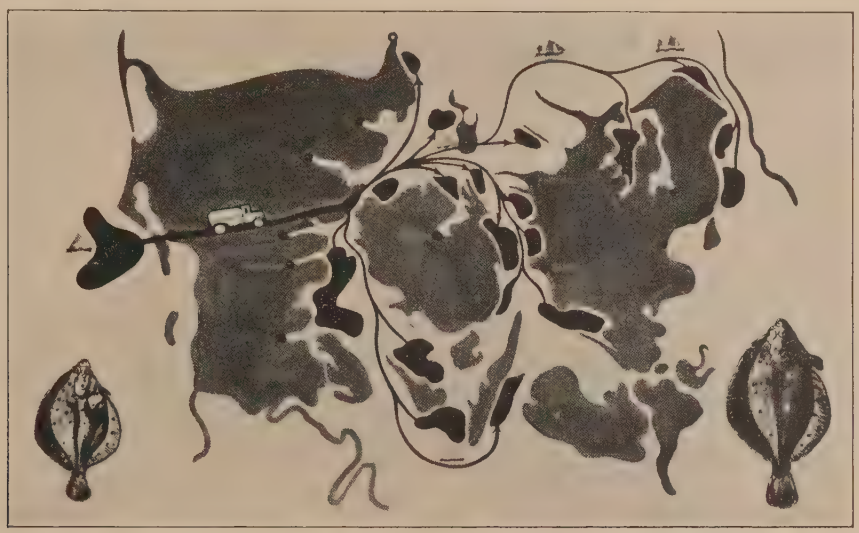


Fig. 1. Schematic presentation of the experimental transplantations of plaice from the North Sea to the Belt Seas in 1929. As to explanation see text below.

Fig. 1 represents in a schematic way the regions where the fish were caught and the regions of liberation. The proportion between the areas of the latter regions corresponds fairly well to the numerical distribution of the fish transplanted. In the left corner below is given the average size of a plaice at the time of transplantation (abt. 21.5 cm.) as compared with the figure in the right corner representing the average size after a stay of 6 months in the Belt Sea (abt. 30.2 cm.). By way of control 2 800 of the transplanted and 2 800 of the "local" Belt Sea fish were marked; all of them had a length of 20—25 cm., and they were put out in 28 different localities. On December, 31st, 1929, 21 per cent. of the former and 55.2 per cent. of the "local" plaice had been re-captured. On December, 31st, 1930, the figures were 32 and 60 per cent., respectively. Like in 1928 the growth in 1929 of the transplanted fish was very rapid, averaging abt. 10 cm. in a year, whereas the Belt Sea fish had grown by abt. 7 cm. only within the same period.

The Belt Sea fishermen, who on many occasions could easily identify the North

Sea fish by their more oblong shape and their protruding snout were very glad of the transplantation, as it added considerably to their incomes. In a racial investigation of 300 plaice caught by fishermen N. of Funen on July, 26th—27th, 1929, it turned out that no less than 53.6 per cent. of the fish belonged to the North Sea race, i.e. they were transplanted plaice. In an investigation made as late as July, 1930, abt.

Fig. 2. Distribution of plaice transplanted to the Belt Sea in 1931. Figures in Roman type above the line denote quantity in kg., figures in italics below the line denote number (calculated). Places of liberation are indicated by points; where two points are connected with a line, the amount of plaice given was divided between the places in question.

10 per cent. of the larger commercial plaice from the Great Belt were still found to originate from the transplantation of 1928—1929.

For the transplantation experiments of 1928 and 1929 the Government had granted an annual sum of 60 000 Kr.; in 1930 no aggregate amount was granted, but two associations of fishermen, viz. of Isefjord and Kerteminde, which had collected money for a transplantation to their respective waters, were subsidized by the Government, so that 2 small local transplantations might be carried out. At both places 100 of the plaice were marked; at the end of October, 1930, the percentages of re-capture were 42 and 30, respectively.

In 1931 the Government granted an annual amount of 60 000 Kr. for three years to come for the continuation of the transplantation experiments in the Belt Sea[1]). From April, 8th, to May, 2nd, 1931, abt. 1 189 500 plaice with a weight of abt. 114 472 kg. were transplanted from the Horns Reef Area to the Belt Sea.

The distribution in number and quantity to the different parts of this water appears from Fig. 2 and the below survey.

	Number of Individuals	Weight in kg.
South-Western Kattegat	18 800	2 000
The Isefjord	95 800	9 225
Great Belt and Lesser Belt ..	927 400	87 030
Western Baltic	91100	9 167
The Sound	56 400	7 050
	1 189 500	114 472

Weight per score abt. 1.9 kg.

In this year the fish were to be kept in fish-ponds for 3 days at Esbjerg and for 2 days at Fredericia. 2 300 of the transplanted plaice, but only 850 of the "local" Belt Sea fish were marked; for in 1931 it proved very difficult to procure plaice of the proper size (20—25 cm.) from the Belt Sea, the 1929-year class, which was to make out the bulk of the fish to be marked, being a very bad year class. At the end of January, 1932, were re-captured no less than 34.1 per cent. of the transplanted fish, more than in the same period of any previous year, but only 24.1 per cent. of the "local" fish. This is the first time when the percentage of re-capture was higher for the transplanted than for the "local" fish. The reason is no doubt that because of the said difficulties in providing young plaice for marking the fish would have to be collected from many different places, and hence would have to be transported a long way; thus we see here a proof of the importance of the transport question for the transplantations.

Fig. 3 shows the percentages of re-capture of plaice marked in April, 1931 in the different places of liberation, calculated at the close of January, 1932. As will be seen, the heaviest re-captures of transplanted North Sea fish (figures in Roman types above the line) were made near Fredericia, from where the transplantation was carried out (Baaring Vig 66 per cent., Aarø 43 per cent., Halk Hoved 49 per cent.). The smallest percentages of re-capture are met with in places to which the transport was long: the Sound 17 per cent., Langeland 18 per cent., Ristinge Bugt 11 per cent., etc. The percentages of re-capture of the "local" fish (figures in italics below the line) are highest when the plaice are caught and marked on the spot, e.g. in the Kerteminde Bugt, and lowest where the transport, starting from Korsør, was longest, viz. in the Lesser Belt. Even if we shall have to consider the fishing intensity in the

[1]) The amount for the year 1932 has later been reduced to 50 000 Kr.

different localities, the final result no doubt may be taken as a proof that a long transport in well boats reduces the viability of the plaice a good deal.

In 1931, too, the growth of the marked transplanted plaice proved to be considerably more rapid than that of the "local" fish. As will be seen from Fig. 4, the latter had in October grown by little more than 4 cm. on an average, the transplanted plaice, however, by more than 8 cm.; many of them had even grown by 11 cm. In

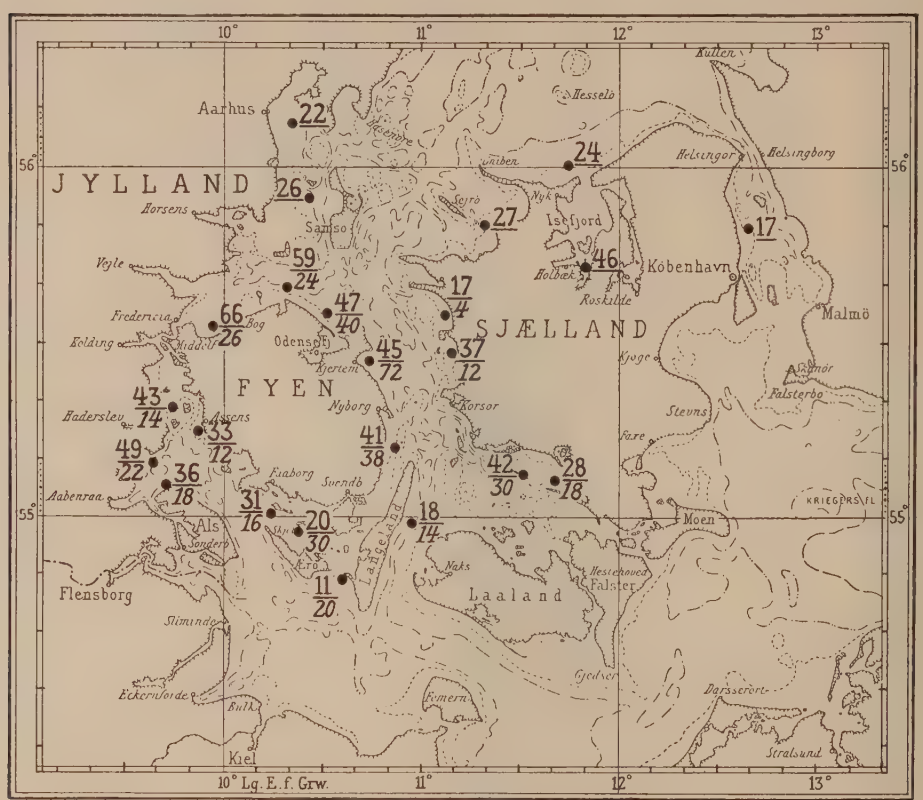


Fig. 3. Percentages of re-capture of plaice in the experimental transplantations of 1931, end of January, 1932. Transplanted North Sea plaice: Figures in Roman type above the line. Indigenous Belt Sea plaice: Italics below the line.

January, 1932, the average length of the transplanted plaice had increased by no less than 11.9 cm., indeed, some of them had grown by 16 cm.; during the same period the marked "local" plaice had grown by no more than 6.2 cm. It is rather difficult to state the reason why the transplanted North Sea plaice should grow twice as fast as the "local" ones. Dr. A. C. Johansen was of opinion that the North Sea plaice do not propagate during the first year after the transplantation, whereas the indigenous plaice of a corresponding size do so, and hence are checked in their growth; but during the winter 1931—1932 we have received not a few marked North

Sea fish dating from the transplantation of 1931, full of roe, and still growing very rapidly, so that this theory must be given up. More probably the cause is that the North Sea plaice, which at the time of transplantation to the Belt Sea are 4 or 5 years old, are considerably older than the indigenous Belt Sea fish of the same size, which are abt. 2 years old, and that they originate from localities with a surplus of plaice and consequently a very strong competition for food among the fish. Hence,

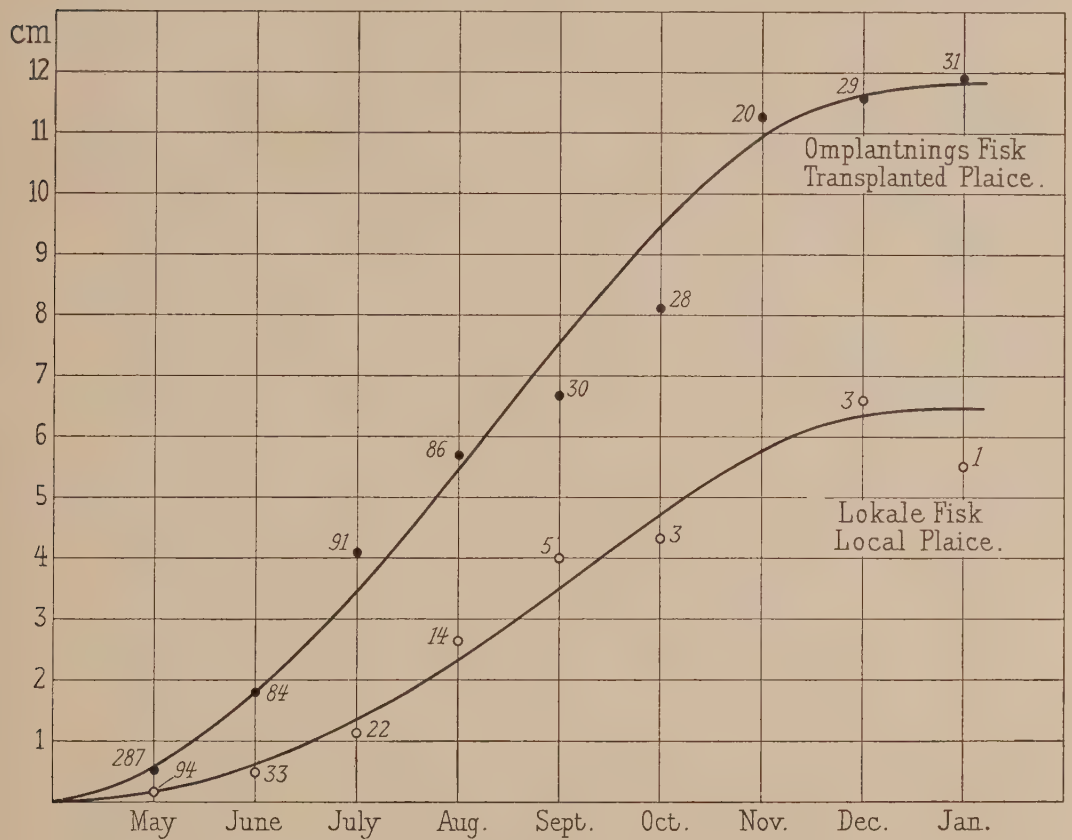


Fig. 4. Growth curves for plaice marked in the experimental transplantations of April, 1931. The circular and triangular points denote average growth of re-captured marked plaice for each month. Figures at the points denote number of individuals re-captured per one month.

when they are transplanted to places with abundance of food, like the Belt Sea they are so much more eager to feed than the indigenous fish, that the result is a far more rapid growth.

The marking experiments have shown that on the whole the transplanted plaice do not migrate very far: they stay near the place where they have been liberated. This no doubt also explains the fact that a very small number of the transplanted and marked plaice are caught by foreign fishermen. In one place, only, the fish transplanted are caught by foreign fishermen, viz. in the Sound where $^1/_3$ of the

marked and re-captured fish are caught by Swedish fishermen, and so Sweden ought to bear $^1/_3$ of the costs of the transplantations to the Sound.

Obviously the transplantations to the Belt Sea have gradually overcome the difficulties of the start. The experiments are conducted by F. V. Mortensen, Fishery Director, in collaboration with the Danish Biological Station; in all cases a contract has been made with a fish merchant, stipulating terms with regard to keeping in fish ponds, control, etc., to deliver the transplantation fish at the places of transplantation at a fixed price per kg. of perfectly viable fish; dead or damaged fish are not paid. The fish are controlled at the places of transplantation by the vessels of the Fishery Inspection assisted by the Danish Biological Station, which also marks the fish. Out of the annual grant of 60 000 Kr. abt. 20 000 Kr. are spent on the markings and other scientific measures of control relating to the transplantation. An amount of 2 Kr. is paid for each mark accompanied by detailed information as to place of capture, size of the plaice, etc.

Now, do these transplantations pay? The answer must no doubt be in the affirmative. As we have seen the costs of each of the great transplantations were 40 000 Kr. Naturally, it is very difficult to procure a perfectly exact account of the profits of the commercial fishery derived from the transplanted fish. However, it is possible to get an idea of the size of the amount, and in two ways.

1. A minimum figure may be found by considering the percentages of re-capture of the transplanted and marked plaice, as it may be reckoned that at least the same percentage of the other transplanted fish is caught; but still, this will only be a minimum figure, because many re-captured marked plaice are not returned, either because the mark is overlooked or because it falls off after some time. As mentioned above the total re-capture of fish marked and transplanted in 1929 amounted to $^1/_3$; their weight averaged at least 300 g., and their price may be put at 90 Øre per kg., i.e. 27 Øre apiece. One third of the 1 047 000 plaice transplanted in 1929 gives 349 000 pieces, and the value will be 349 000 $\times$ 0.27 = 94 230 Kr. — Of the plaice marked and transplanted in 1931 34.1 per cent. had been re-captured at the end of January, 1932; this figure is likely to increase considerably later on; but if here, too, we reckon a total re-capture of $^1/_3$ only, we arrive at a profit derived from the fish transplanted in 1931 of 107 000 Kr. — If later on the percentage of re-capture should rise to 40, the profit will be abt. 128 500 Kr.

2. Analyses of the catches of the Danish fishermen, similar to those made in 1929 and 1930, showed in Sep.—Nov., 1931 that on an average 33 per cent. of weight of the fishermen's catches about the Belt Sea consisted of North Sea fish. This surprisingly high percentage is connected with the fact that all the years since 1927 have been poor brood years for the plaice of the Belt Sea, so that the indigenous stock of 1931 has been unusually small. Judging by experience from previous years it might be expected that the weight percentage of transplanted fish would fall

somewhat during the winter. Indeed, in a new investigation of the catches of the fishermen from many different regions of the Belt Sea in January—February, 1932, (297 plaice were examined) it turned out that now the transplanted plaice averaged only 20 per cent. of the catches of the fishermen. If we suppose that for the whole of the year April, 1931—April, 1932, the part of the catches of the fishermen which is made out of the transplanted North Sea fish will amount to 25 per cent. and that the total yield of the plaice fishery in the Belt Sea during the same period will amount to fairly the same quantity as in previous years, i.e. abt. 700 000 kg. at an average price of 90 Øre per kg., the part of the catches originating from the transplantation of 1931 will amount to 175 000 kg. or abt. 157 500 Kr. However, it should be emphasized that so far the said figures are naturally quite inaccurate, and accordingly are given under all reserve. On the other hand the effects of the transplantation may be traced for much more than one year after the transplantation because, as mentioned above, the transplanted fish constitute a perceptible part of the catches of the fishermen as late as 18 months after the transplantation.

Thus the results of the two methods of calculation made partly on the basis of the catches of the fishermen, partly on the basis of the results of the marking experiments, correspond fairly well and seem to indicate that the fishermen have profited highly by the transplantations.

As mentioned above, the experimental transplantations to the Belt Sea will be continued in 1932 and 1933, presumably on the same principles as in 1931. Unfortunately the marking experiments show a too high percentage of re-capture within the first month after the transplantation; in several cases more than 20 per cent. of the marked fish are caught within this period, i.e. before their size have increased materially. Hence, an energetic work has been done for the introduction of a period of protection of the transplanted fish, but so far without success. Another measure which would no doubt contribute to increasing the yield of the transplantation considerably, is the introduction of a higher minimum size for the transplantation areas. This has already for several years been kept up in the parts of the Limfjord where plaice are transplanted on initiative of the Government. For the moment, however, there are no prospects of introducing such an increase of the minimum measure.

On the part of the fishermen proposals have been made to contribute economically to the transplantations by levying a certain tax (50 Øre per motor h.p.) upon the fishermen of the district, but up to now it has proved impossible to carry through this proposal. If the experimental transplantations give satisfactory results also in the years to come, the question of a materially increased and extended transplantation will become urgent, and this will no doubt be followed by a demand on the part of the Government for an effective protection of the transplanted fish. However, it should be emphasized that only through an economic collaboration with Sweden and Germany may the transplantations be extended to a degree

so as to be of decisive importance for the preservation of the stock of plaice in the waters within the Skaw. There is no doubt that by such transplantations the Baltic race will gradually be considerably intermixed with the North Sea race, but there is no reason to believe that this will have any harmful consequences whatever; the descendants of the two races will undoubtedly prove to have preserved the good qualities of both races.

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